TRANSACTIONS

of the

Royal Canadian Institute

XXIII

VOLUME XXII — XXIV

1938-1939 — 41

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TRANSACTIONS

OF THE

Royal Canadian Institute

No. 47 OCTOBER, 1938 VOL. XXII, PART I

THE DEPOSITION AND ALTERATION OF VARVED CLAYS

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During the summer of 1936 the writer was engaged in a geological survey of a part of Eagle Lake and adjacent areas in the District of Kenora, Ontario. The entire map-sheet is underlain by pre-Cambrian formations, glaciated by the Labradorean ice and later covered with pleistocene deposits which include for the main part boulder-clay, immediately covering the bedrock surface, and an overlying mantle of varved clays and beach deposits of lacustrine origin. The deposits are thin and for the most part mantle the hilly rock surface without concealing its undulations. As a result the rock is everywhere exposed along the lake shores through the removal of the drift by wave-action, and sections of the pleistocene are of frequent occurrence and occasionally useful for study. Even better, because fresher, exposures were to be seen in the costine trenches recently dug by miners in the search for gold-bearing veins. The phenomena which are studied in this paper were partly observed in the last-mentioned connection.

I. *Deposition*—In general the boulder clay is not of great thickness and in many parts is represented only by a few boulders. Above these the varved clay for the most part has a thickness of three or four feet. It is composed of thin beds of clay separated by white partings of calcareous material. A study of the conditions of deposition of such clays may here be of interest.

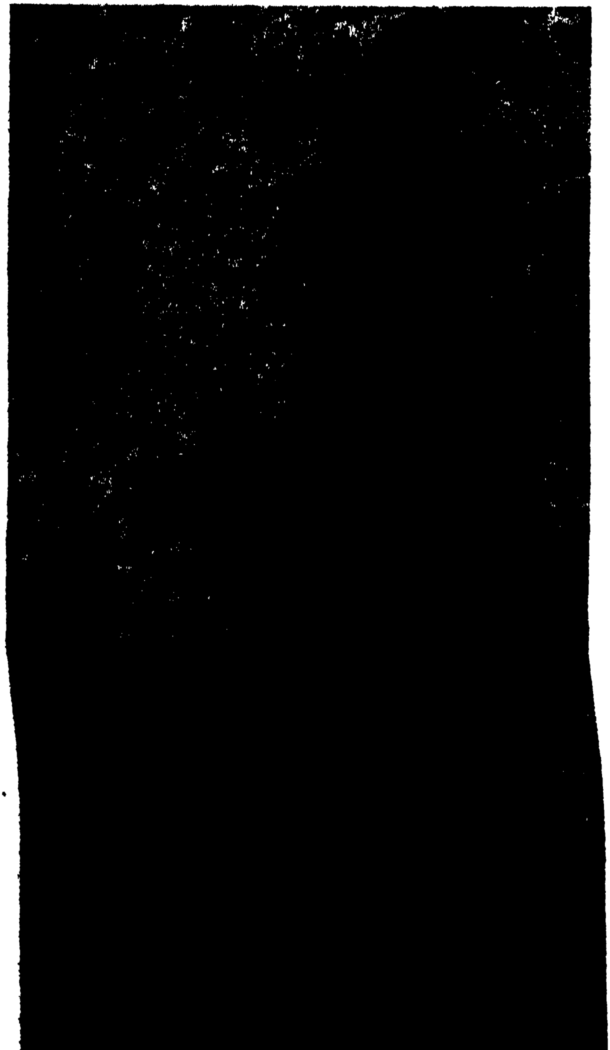
The lakes in which the deposition took place were almost certainly ice-dammed lakes and the climate colder than now. While the water in summer was probably not at as high a temperature as at present, the winter conditions were almost identical for reasons which may be stated. It is well known that cooling water reaches a maximum of density at a temperature between 39 and 40 degrees Fahrenheit (about 4° Centigrade). Below this temperature it expands slightly and decreases in density to 32° (0°C.) where crystallization takes place, accompanied by further expansion and decrease in density. Owing to these facts the freezing of a lake follows a certain definite course. The water is cooled at the surface by conduction of its heat into the air which is at a lower temperature. As a result the cooled water on the surface becomes heavier than that below and a downward convection of the cold water is established, the warmer water below rising to the surface and being in turn cooled until its density is greater than that below. This condition continues until some of the water reaches

the temperature of maximum density (4°C.), and after sinking remains permanently at the bottom of the lake. As more water reaches maximum density the lake gradually fills from the bottom to the surface with water at 4°C. The water on the surface then ceases to sink and as it cools further becomes lighter and remains on the surface until it reaches 32°F. (0°C.), when after losing 80 calories of latent heat per gramme it crystallizes. In a body of still water frozen over the conditions are then as follows. The upper surface of the ice has nearly the same temperature as the air to which it is exposed, while the lower surface has, at 32°, the same temperature as that of the water immediately in contact with it.. From the under surface of the ice downward the water decreases in temperature and increases in density for a short distance until the temperature of maximum density is reached, which continues from that level to the bottom. The ice thickens by the transfer of latent heat from the water at 32°F. to the ice at 32°F. and thence through the ice-sheet into the air.

As water cools its capacity for the solution of gases increases. The water of a frozen lake therefore is more highly acidulated by absorption of carbon dioxide than the warmer water of the summer which at present ordinarily rises to a temperature of nearly 60°F. The solution of calcium carbonate in the water depends on that acidulation, and its deposition from the water probably on a decrease in the acidulation, which would be brought about by a warming of the water. On this basis we can perhaps correlate the deposition of the varves with the seasonal changes which must have been taking place at the time of the sedimentation.

(a) During the winter the surface of the soil is frozen and precipitation remains upon it in the form of snow. Any slight liquefaction of the snow is frozen before it has time to run off in the form of drainage. It cannot penetrate the frozen upper layer of the soil. Underneath the frost layer, the unfrozen ground water continues to work its way slowly into the streams and lakes, carrying with it no solid sediment, but a considerable supply of dissolved salts, especially calcite. The cold acidulated water of the lake is well adapted to receive these, and retain them without precipitation, so that a condition of saturation is approached, perhaps nearly reached.

(b) With the arrival of spring the ice-cover of the lake melts more slowly than the snow on the adjacent land. The floods which follow the liquefaction of the snow and the thawing of the surface soil carry large amounts of solid sediment into the lake. The coarser parts are deposited near the shores, while the finer clay is carried further out and settles gradually over the bottom of the lake for great distances, covering the bottom of even large lakes. The floods once over, the streams become



Varved clay in a costine (trench) on the Gold dale mining property at Eagle Lake. Below can be seen the unaltered varves with white calcareous partings between the more argillaceous layers. These distinct markings gradually fade out as they pass upwards into the weathered part near the surface, where the vertical cracks due to horizontal shrinkage become more prominent. The vertical distance from top to bottom of the illustration is about five feet. The top is near the surface of the ground. The shadows are due to trees.

clear, much reduced in volume, and the amount of silt carried out is negligible.

(c) As the lake waters gradually warm by direct solar radiation and conduction from the air after the disappearance of the ice, and are further warmed by the inflow of warm surface waters, the capacity of the water to retain carbon-dioxide is decreased, and the deposition of part of the solids dependent on its presence would follow. This includes all carbonates but mainly calcite. The actual condition is that the water in the depths of the lake remains colder all summer than that on the surface. As is well known, the species of fish that prefer cold water are then found at a considerable distance below the surface. The calcite released from solution in the warmer water near the surface would sink until it came to the colder and more acidulated depths which would redissolve it, become saturated, and finally deposit calcite as a precipitate at the bottom. We may therefore refer the formation of the white partings in the clay to the summer season. The predominantly argillaceous layers must also be conceded to contain some calcite, apart from the presence of numerous calcareous concretions in them.

II. *Alteration by Weathering*—After the subsidence of the glacially-dammed waters, the varved deposits were exposed to weathering by rain charged with carbon-dioxide. The result is the resolution and leaching-out of the carbonates so that the varved structure and appearance are lost, the remaining clay appearing uniform. The removal of carbonaceous matter and possibly other salts from the clay itself would account for the vertical fissures due to horizontal shrinkage and the vertical thickness of the weathered deposit must also be considerably reduced.

The reproduced photographs accompanying this article, demonstrate the appearance of the unaltered deposit and of its weathered equivalent.

THE BLAIRMORE CONGLOMERATE AND ASSOCIATED SEDIMENTS

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Introduction

The Lower Cretaceous non-marine sequence in the foothills and front ranges of the Rocky Mountains of Alberta consists of two formations, the *Kootenay* below and the *Blairmore* above. The line of demarcation between these formations is a conglomerate bed long known as the Kootenay conglomerate but more recently as the Blairmore conglomerate.

This conglomerate has been known and studied for some fifty years by geologists and prospectors in the foothills area of Alberta. To the prospector it has proved a very useful indicator as to the position of the coal seams which occur either immediately below or immediately above it. As the conglomerate usually stands out fairly conspicuously in the section, whereas the coal-bearing beds, being softer and more easily eroded, are more commonly covered, the significance of the conglomerate to the prospector cannot be overrated. To the geologist, the conglomerate proves very useful in mapping as it separates the underlying Kootenay formation from the overlying Blairmore formation. Certain horizons in these two formations are very similar in appearance and the position of the conglomerate bed in the section greatly facilitates their distinction.

The conglomerate, however, raises certain problems which have, so far, not been solved to our complete satisfaction. Many questions arise as to the stratigraphic significance of the formation. These questions must be answered before the importance of the conglomerate bed can be appreciated and the stratigraphy of the underlying and overlying formations fully understood. They may be stated as follows:

1.—Is the Blairmore conglomerate of exactly the same age throughout the entire extent of its outcrop, a distance of about 400 miles?

2.—Does the Blairmore conglomerate represent a stratigraphic break in the succession, and if so, of what magnitude?

3.—What is the origin of the boulders in the Blairmore conglomerate?

It is the author's intention to attempt an answer to these questions, at least in part. In order to do so the lithology and extent of the conglomerate and associated formations must be discussed in detail.

Historical

The Lower Cretaceous in the foothills and front ranges is a non-marine sequence represented by two formations,—the Kootenay formation below

and the Blairmore formation above. The upper beds of the Blairmore probably represent Upper Cretaceous time. G. M. Dawson introduced the term Kootanie* for a succession of beds in Crowsnest pass in 1885(1). Dawson included in his Kootenay our present day Fernie shale (Jurassic), the Kootenay and most of the overlying Blairmore formation. Some fossil plants obtained from the coal-bearing beds in the Kootenay were determined as Lower Cretaceous by Sir J. W. Dawson(2) whereas some obtained from the top of the section were believed to represent a Dakota flora and, therefore, Upper Cretaceous. For this reason the upper beds of the succession (the uppermost beds of our present Blairmore) were excluded from the Kootenay, which term was reserved for the Lower Cretaceous deposits. Dawson mentioned the conglomerate beds associated with the Kootenay series and considered that the chert pebbles in the conglomerate were derived from the underlying Palaeozoic limestones. He measured a section in the vicinity of the present town of Coleman.

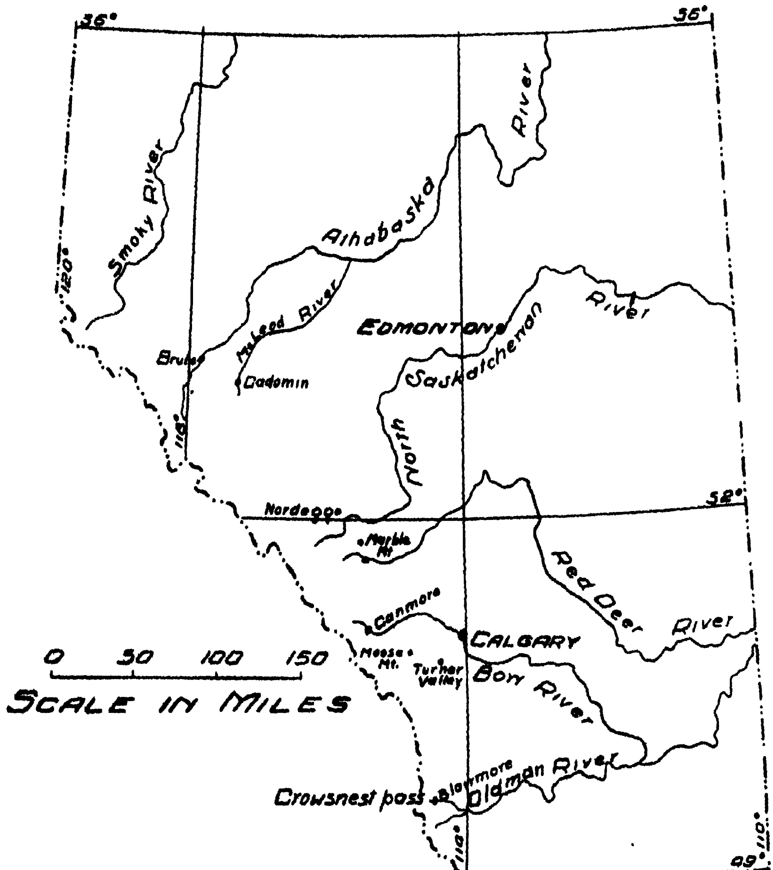
In 1900 Mr. J. M. McEvoy(3) measured the section of the Cretaceous beds at Fernie, B.C., in Crowsnest pass. He stated that Dawson's Kootenay series comprised the lower and middle part of the section but he mentioned no dividing line between the Lower and Upper Cretaceous. The Fernie shale was included at the base of the section. He gave the age of the Kootenay as Lower Cretaceous on the evidence of fossil plants identified by Dawson(4).

W. W. Leach, in 1902(5), studied the section at Blairmore and Coleman. His general section limits the different formations as we now know them but he does not name them. He recognized our present Fernie shale at the base of the section, then the coal-bearing beds (Kootenay) followed by a conglomerate bed (Blairmore conglomerate). This is overlain by his fourth series, our present Blairmore formation. In the sections of the coal-bearing beds studied in various localities Leach always included the conglomerate as part of that group.

When Leach returned to Crowsnest pass in 1911 he named the formations he had previously delimited. The black shales at the base of the section he definitely termed *Fernie shale* and relegated it to the Jurassic. For the coal-bearing beds above the Fernie he used Dawson's term *Kootenay* in a limited sense including with it the conglomerate at the top which he called the *Kootenay conglomerate*. The beds above the conglomerate he termed *Dakota?* He considered that the Dakota (?) "overlies the Kootenay without any evidence of unconformity unless the conglomerate at the top of the Kootenay should mark a short cessation of

*The present spelling "Kootenay' was adopted by the Geographic Board of Canada on the 5th of March, 1900. 18th Report, p. 151.

deposition at that period"(6). In 1912 Leach again returned to the Blairmore area and in the Summary Report of the Geological Survey for that year(7) his geological map was published. In this map Leach introduced the term *Blairmore* (*Dakota?*) for the beds above the conglomerate.



Outline map of the southern portion of Alberta showing the localities referred to in the accompanying paper.

Bruce Rose(8) studied the Blairmore section in 1915 and 1916 and used the term *Blairmore formation* for the beds above the conglomerate and placed the conglomerate in the Blairmore rather than in the Kootenay as he noticed an unconformity at the base of the conglomerate.

F. H. McLearn studied the section in 1915(9). On the evidence of

fossil plants he suggested a Dakota age for the upper 200 feet of the Blairmore and an uppermost Comanchean age for the lower part of the formation.

B. R. McKay in 1931[10] and 1932[11] especially stressed the unconformity at the base of the conglomerate. He placed the conglomerate at the base of the Blairmore which he considered Lower Cretaceous in age.

E. W. Berry[11a] in a study of the fossil plants from this section in 1929 suggests a Barremian age for the Kootenay flora and an Aptian-Albian age for the Lower Blairmore. He considered the flora from the uppermost Blairmore to be Cenomanian in age.

LITHOLOGY OF THE CONGLOMERATE

The Blairmore conglomerate varies little in lithological character throughout the foothills and mountains. It is composed of pebbles of chert and quartzite cemented in a matrix of, usually, calcareous sandstone. The chert may be grey, blue or pink in colour whereas the quartzite pebbles vary from a white to a buff or yellow colour. The proportion of chert to quartzite is apt to vary from place to place. Occasional outcrops have been observed at which the pebbles are preponderantly chert whereas at other outcrops they are mostly quartzite. They are usually well mixed. The proportion of matrix to boulders is variable also but this variation seems to bear a distinct relation to the position of the outcrop with the shore-line to the west when this bed was being deposited. As a rule the boulders appear as the predominant part of the bed and they usually make up over fifty per cent of its total volume.

The Blairmore is a well sorted conglomerate. In any one exposure the pebbles do not vary greatly in size though there is a certain variation in size in different exposures. The average size of boulders and pebbles in the exposures in the foothills is about an inch in diameter. They are seldom found much smaller than half an inch but they may be as large as three inches in diameter. In Crowsnest pass, in the Michel and Fernie fields, they may be found still larger and the amount of sandy matrix proportionately less. Such changes are accounted for by the proximity of these areas to the old shoreline. It seems to be a fact, nevertheless, that the conglomerate disappears towards the east not so much by the pebbles becoming finer and finer but by the pebbles becoming fewer and fewer in the sandy matrix.

The shape of the pebbles varies considerably. They all show the effects of water action by being flattened to some degree and are roughly of an oval shape. It is surprising, however, that they are seldom of the flatness of well-worn beach pebbles. The chert pebbles are usually more angular

than those of quartzite. Chert pebbles may be found in the conglomerate in the foothills which show very little sign of water action though far from their source of supply. The angularity they display is probably the result of breakage in transit.

EXTENT AND CHARACTER OF THE FORMATIONS

To arrive at a proper understanding of the relationship of the Blairmore conglomerate to its associated sediments it is necessary to trace the outcrops of the formation throughout its known extent in the foothills and mountains. It is not our intention, however, to discuss the lithology of the Kootenay and Blairmore formations except in very general terms. These formations remain, on the whole, remarkably constant in lithological character throughout. They consist of alternate beds of buff or grey to greenish-coloured fine-grained sandstone and dark grey or greenish-coloured shale. Where coal occurs in the section, the accompanying beds are usually buff-coloured sandstone and dark grey shale. Where free from coal the beds usually assume a light grey or greenish grey tint. Small differences in lithology appear at certain horizons in different outcrops in confined areas but they are not of sufficient importance to be considered in the present discussion. The changes in thickness and lithological changes over wide areas will be discussed in the following pages.

In the Boundary Survey report(12) Daly mentions the absence of Cretaceous rocks within the mountains. In the foothills area in front of the mountains, Stewart(13) did not find any of the Kootenay-Blairmore group in the southern area. It is probable, however, that it is present in an unmapped area immediately east of the front ranges.

The farthest south that the Kootenay-Blairmore succession is known to outcrop in Canada is in the Flathead valley in the mountains just north of the International Boundary(12). Mackenzie gives a thickness of 1,100 feet for the Kootenay, 85 feet for the conglomerate and 2,000 feet for the Blairmore which is poorly exposed in this area. He placed the Blairmore in the Upper Cretaceous and considered that the conglomerate at the base overlies the Kootenay disconformably. He believed that the pebbles in the conglomerate originated in the Devono-Carboniferous limestones which underlie the Mesozoic succession. The Kootenay-Blairmore in this basin is exposed in an area about six miles long but does not extend as far south as the International Boundary.

On the South Fork of the Oldman river (now known as Castle river) Mackenzie(15) gives a thickness of 1,285 feet for the Fernie (base not exposed) and Kootenay combined, the conglomerate being included in the

Kootenay. His measurement for the Blairmore is 2,500 feet. He mentions a second conglomerate occurring in the Blairmore at this locality.

Stewart[13] gives a thickness of 600-750 feet for the Kootenay in the southern foothills. The conglomerate at the base of the Blairmore is from six to ten feet thick but occasionally reaches 30 feet. No good measurements of the Blairmore in this area could be obtained.

There is considerable variation in the thickness of this set of beds in Crowsnest pass. Mackay[11] gives a thickness of less than 400 feet for the Kootenay at Burmis at the east end and 800 feet at Coleman farther west. The thickness of the Blairmore in the same area ranges from 2,100 to 3,000 feet. Across the divide in British Columbia in the Crowsnest field, Mackay[10] gives a thickness of 3,500 feet for the Kootenay and over 6,000 feet for the Blairmore. These figures show very plainly the thickening of the formations in a westerly direction. The Crowsnest coal field extends north as the Elk River coal field for some 60 miles[16].

In the Moose Mountain area south of Bow river Cairns[17] reports that the Kootenay averages about 240 feet in thickness, the Blairmore from 900 to 1,700 feet and the conglomerate at the base from 10 to 30 feet. The same set of beds are known to outcrop farther west behind the front range at the head of the south branch of Sheep creek at Burns mine where the thicknesses are much increased.

In the Pekisko Hills, as representative of Turner valley area, Hume[18] gives a thickness of 100 feet for the Kootenay and 1,200 to 1,500 feet for the Blairmore. The basal bed of the Blairmore is a conglomeratic sandstone. The McDougall-Segur sandstone and the Home sandstone are two productive horizons in the Blairmore.

The Kootenay-Blairmore succession is not fully exposed on Bow river east of the front range; only the upper part of the Blairmore outcrops[19]. In Cascade valley behind the front ranges most of the section is exposed. The names Kootenay and Blairmore were not originally applied to this section but were used by MacKay in mapping the coal basin[20]. MacKay* places 1,340 feet of beds in the Blairmore. The upper 600 feet of the formation has several massive conglomerates. He draws the line between the Blairmore and the Kootenay at the base of a coarse-grained sandstone which overlies a 45-foot bed of black shale. There is no conglomerate at this horizon. This would place 3,050 feet of beds, with the coal horizon, in the Kootenay. It is doubtful if this division of the beds corresponds with that of other areas where the Blairmore is always thicker than the Kootenay. As MacKay states that no continuous section of either forma-

*Personal communication.

tion could be obtained, the conglomerate bed at the base of the Blairmore may not have been exposed. If the conglomerate bed is missing in Cascade valley it is the only known section where it has failed.

In tracing this set of beds north of the Bow in the foothills, only the upper part of the Blairmore is exposed on the west of Wildcat hills according to Hume[21]. Farther north on Red Deer river east of Hunter Valley well, the basal Blairmore is exposed. The conglomerate is present, is massive and quite thick and is underlain by 150 feet of Kootenay beds with coal, the base of the formation being faulted[22]. Hume states that the conglomerate with the accompanying sandstone can be traced north to James river.

At Marble mountain, on Tepee Pole creek, a tributary of the James on the north side, the Blairmore formation is exposed around the Palaeozoic fold. The conglomerate is well exposed and is about 35 feet thick. The Kootenay is practically gone, the conglomerate resting on the Fernie shale which becomes sandy in the upper beds. The whole succession is about 1,300 feet thick. There is no sign of coal*.

Nearly the same condition obtains at Nordegg. Allan and Rutherford[23] show that the conglomerate at the base of the Blairmore lies directly on the Fernie. The upper beds of that formation are sandy and probably marine. It is doubtful if these sandy beds at the top of the Fernie should be termed Kootenay. The conglomerate varies in thickness from 10 to 35 feet. The Blairmore attains a thickness of 1,500 feet with an average of about 1,000 feet for the area. Coal seams occur near the base of the Blairmore which is the producing horizon in this area. It is known locally as Kootenay coal.

In the Bighorn basin west of Nordegg the formations thicken considerably. Mallock[24] gives a total thickness of the Kootenay-Blairmore as 5,458 feet but he does not divide the two formations at the conglomerate. A division of the formations at the conglomerate shows the Kootenay with a thickness of 1,467 feet and the Blairmore with 3,991 feet with a ten-foot conglomerate bed at the base.

In working north from the Nordegg area along the Blackstone, Brazeau and Pembina rivers, Allan and Rutherford[25] use the word Kootenay for the whole Kootenay-Blairmore succession. They divided it into two members,—the upper, the McLeod member, which corresponds to the upper part of the Blairmore, and the lower, the coal-bearing member which includes the lower Blairmore, the conglomerate, and the true Kootenay.

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*Private information from The Canadian Western Natural Gas, Light, Heat and Power Company, Limited.

The coal horizon is mostly in the Lower Blairmore. No good measurement of the thickness of the formations could be obtained.

The same nomenclature was used by Rutherford[26] in the extension of this work to Athabaska river. He gives a thickness of 900 feet for the beds below the conglomerate on Folding mountain.

The area along the McLeod and Athabaska rivers has also been reported on by MacKay[27,28]. He used a new nomenclature for the section. For the Blairmore conglomerate he introduced the term *Cadomin*; for the formation below the conglomerate, the term *Nikinassin;* for the coal-bearing beds in the Lower Blairmore, *Luscar,* and for the Upper Blairmore, *Mountain Park formation.* All the coal occurs in the Luscar formation,—the Nikinassin, or the Kootenay of the southern area, being barren. The flora of the Luscar formation is considered to be of Lower Blairmore age by Bell[9] (in MacKay[25] pp. 13 and 14). MacKay gives a thickness of about 1,000 feet for the Nikinassin, 5-70 feet, with an average of 25 feet, for the Cadomin conglomerate and 1,950 feet for the Luscar, which measurement may include some of the Mountain Park sandstone. The Mountain Park formation thins very rapidly to the north. On Brazeau river it is 825 feet thick, thinning to 320 feet at Luscar, and is probably not present as a distinct formation at Brule on the Athabaska.

North of the Athabaska our knowledge of these rocks is largely confined to two reports by McVicar[29,30]. He used about the same nomenclature as that of Rutherford[26]. His Kootenay embraces all the coal-bearing beds and extends down to the top of the Fernie. For the upper barren beds (upper part of the Blairmore) he introduced the term Sunset sandstone. The section seems to thicken in a northerly direction as he gives a thickness of 3,600 feet for the Kootenay in the foothills and 3,000 feet for the Sunset sandstone. Two conglomerate beds come into the section and both are very thick. It is difficult, therefore, to correlate the section with that on Athabaska river.

Farther north on Peace river Lower Cretaceous beds occur, but as these differ considerably from the Kootenay-Blairmore succession, it seems best for the present to leave them out of the discussion. A curious feature, however, may be mentioned. McVicar notes a heavy sandstone bed, the Sunset sandstone, coming in on top of the succession which, according to its stratigraphic position must be equivalent to the Mountain Park sandstone, and he gives a thickness of 3,000 feet for it. On Peace river, marine shales occupy the same horizon[31,32]. As MacKay notes the thinning of the Mountain Park sandstone toward the north which would harmonize well with the conditions on Peace river, it leads one to believe that McVicar included some overlapping Belly River beds in his succession believing them to be Upper Blairmore.

SUMMARY

The Lower Cretaceous deposits in the foothills and mountains show a succession of continental beds extending from near the International Boundary to at least Smoky river, a distance of about 400 miles. A well defined conglomerate bed in the middle of this succession extends the whole distance. It divides the group into two main formations, the Kootenay below and the Blairmore above. This conglomerate marks an unconformity at least locally as shown by the evidence in Crowsnest pass. Both the Kootenay and the Blairmore formations thicken in a westerly direction and this statement holds true to a certain extent for the conglomerate bed at the base of the Blairmore. The Blairmore formation is always thicker than the Kootenay.

A notable change in the succession in a northerly direction is the position of the coal beds. In the southern area north as far as the Clearwater river the coal occurs below the conglomerate, that is in the Kootenay formation. North of this point the Kootenay becomes barren and the coal appears above the conglomerate. This change in the position of the coal horizon has resulted in a new nomenclature for the beds in the northern area. It may be argued that it is the coal horizon that has remained stationary and that the conglomerate has dropped in the section in a northerly direction. Opposed to this is the idea that the coal horizon has risen in the section and that the conglomerate has remained stationary. These arguments will be considered later.

STRATIGRAPHIC SIGNIFICANCE OF THE BLAIRMORE CONGLOMERATE

The first question to be answered concerning the Blairmore conglomerate is,—Does the conglomerate represent the same stratigraphic horizon throughout its whole exposure? This question is a little difficult to answer but we have a certain amount of evidence. It has already been stated that the conglomerate extends from about the 49th parallel north to Smoky river, a distance of about 400 miles. Throughout its entire extent the bed remains remarkably constant both in thickness and lithological character. The conglomerate has been traced by intermittent exposures all the way so there seems little doubt that we are dealing with the same bed north of the Athabaska that is exposed in Crowsnest pass. Its position in the Lower Cretaceous section is practically always the same and the Lower Cretaceous section is bounded both above and below by marine formations which show quite clearly that the whole Lower Cretaceous non-marine sequence is of the same geological age throughout. The main difficulty in the way of accepting this conglomerate as of the same

stratigraphic horizon in all its exposures is the fact that in the south end of its extent coal occurs in the beds below the conglomerate whereas in the north the coal-bearing beds are above the conglomerate. There is, naturally, a tendency to consider the coal horizon as being of the same age throughout with the conglomerate falling stratigraphically in the section towards the north. This contention is not born out by fossil evidence. A flora occurs in the lower Blairmore beds in Crowsnest pass which is considered Aptian-Albian in age. A flora collected in the coal-bearing beds above the conglomerate on Athabaska river is believed by Bell to represent the Lower Blairmore flora. Thus, so far as the fossil evidence is concerned we must consider the coal horizon as rising in the section toward the north whereas the conglomerate remains stationary.

The second question,—whether the Blairmore conglomerate represents a stratigraphic break of any magnitude in the section—is not easily answered from a study of the Lower Cretaceous formations alone. On the strength of fossil evidence so far obtained there is little reason to consider that any stratigraphic break exists. As previously mentioned, Berry suggests a Barremian age for the Kootenay flora and an Aptian-Albian age for the Blairmore flora. If these assignments are correct, there is no reason to assume a large stratigraphic break. That as erosinal interval does occur at the top of the Kootenay is quite evident in Crowsnest pass and it is very difficult to evaluate its importance. The significance of this erosional interval would not arise except for a similar problem at the base of the Kootenay, which may be cited briefly as follows:—The highest fauna found in the Fernie shale, just below the base of the Kootenay, shows that the upper part of the Jurassic is missing from that formation and as the Kootenay sandstones lie apparently conformably on the Fernie with a gradational boundary between, it follows that we would expect to find the upper part of the Jurassic represented in the Kootenay. Not only is this not so but we find that the lower part of the Lower Cretaceous, the Neocomian, is also unrepresented in the section and that the Kootenay represents a still higher horizon in the Cretaceous, *viz.*, the Barremian. This conclusion is difficult to accept when the section is studied in the field on account of the gradational boundary between the Fernie and the Kootenay and the suspicion arises that the Kootenay flora has been placed too high in the scale, and that a stratigraphic break of considerable magnitude occurs at the top of the Kootenay rather than at the base. It is a case of palaeontological evidence versus field evidence. The more one examines the evidence, however, of the whole Lower Cretaceous sequence, the more it becomes plain that the Kootenay-Blairmore is one lithological unit laid down in the same cycle of sedimentation and that the flora of the whole

unit is remarkably similar. This is so much the case that it is extremely difficult to distinguish a Kootenay flora from a Lower Blairmore flora. The weight of the evidence, therefore, seems to be in favour of considering the break at the base of the Blairmore conglomerate as of little stratigraphic importance and that the missing part of the section must be accounted for at the junction of the Fernie and the Kootenay.

ORIGIN OF THE PEBBLES IN THE CONGLOMERATE

The first mention of the conglomerate bed at the base of the Blairmore was by Dawson[1]. He considered that the chert pebbles in the conglomerate were derived from the underlying Palaeozoic limestones. In this he was followed by MacKenzie[12]. Other geologists either do not mention a possible source or they consider that they were brought in from the west. McLearn states that "the conglomerates of the Blairmore indicate an uplift of a land mass to the west and may mark the Sierra Nevadan revolution[9,p.112]. We have, therefore, two ideas regarding the origin of the pebbles in the conglomerate that must be considered.

The idea of the origin of the pebbles in the underlying Palaeozoics must be given first consideration as it was the first to be put forward. The Rundle limestone in the front range where it has been studied carries, in certain areas, a large number of chert nodules. The writer has also observed thin chert beds in the overlying Rocky Mountain quartzite. These are the only Palaeozoic cherts known to the writer in the upper part of the Palaeozoic succession. It was probably Rundle chert nodules that Dawson had in mind when he attributed the conglomerate pebbles to the cherts in the Palaeozoic limestones. In order to obtain chert nodules from the Rundle limestone during Blairmore time, it is necessary to assume a considerable land movement at the end of Kootenay time followed by a period of erosion of sufficient length of time to erode the Kootenay, Fernie, Spray River (if present), Rocky Mountain quartzite and at least part of the Rundle. The date of such disturbance is well fixed as there is no chert conglomerate in any of the formations between the Rundle limestone and the base of the Blairmore. That there is an unconformity at the base of the Blairmore is not to be doubted as the Kootenay has suffered some erosion, as shown in Crowsnest pass, before the Blairmore conglomerate was laid down. How much erosion took place at this time is uncertain but it was probably not a great amount. If there was sufficient erosion to expose the Rundle limestone, then we ought in some places to find the Blairmore conglomerate resting on the eroded surface of the Rundle. Such a contact has never been found. The Blairmore conglomerate has been seen in contact with the Fernie in the foothills where the Kootenay

thins out. It seems reasonable to presume, therefore, that the supply of chert pebbles was not derived from the Rundle limestone in any area where the section has so far been studied.

The fact that the conglomerate beds in the Blairmore become thicker and more numerous as we trace the formation west shows plainly that the source of supply was from that direction. They may of course have been derived from the Rundle limestone on the western side of the Rockies as we cannot trace the Blairmore quite that far. We have, however, evidence to the contrary. The farthest west exposure of the Blairmore, in Elk River valley at Fernie and not far from the Kootenay valley to the west of the Rockies, shows the formations between the Blairmore and the Rundle limestone to be thickening instead of thinning. In the Lizard range west of the Elk valley, the Rocky Mountain quartzite and Spray River formation both attain a thickness of from 1,500 to 2,000 feet which is twice the thickness of these formations farther east in Crowsnest pass. Such conditions would be reversed if there had been an uplift in the western side of the Rockies before Blairmore time and erosion had taken place there.

Further evidence that the pebbles in the Blairmore conglomerate were not derived from the underlying limestones may be deduced from the lithological character of the pebbles themselves. The chert pebbles in the Rundle limestone are all dark grey to black in colour without exception. The chert pebbles in the Blairmore conglomerate vary greatly in colour,—gray, pink and buff. Also, a great many pebbles in the conglomerate are quartzites which are far harder or more consolidated than any quartzite occurring in the Rocky Mountain quartzite above the Rundle, the only quartzite horizon which could act as a source. Altogether the weight of the evidence shows that the pebbles in the Blairmore conglomerate must have been derived from the west of the Rocky mountains, probably from the Selkirk mountains in British Columbia.

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THE DISEASE CAUSED BY *TRAMETES PINI* (THORE) FRIES IN WHITE PINE (*PINUS STROBUS L.*)

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1. INTRODUCTION

Wherever the art of silviculture is highly developed, it is recognized that disease is among the important factors to be reckoned with in the long and often difficult task of bringing timber to maturity. Indeed, silvicultural practice and the regulation of the forest take their shape, in part at least, from this consideration. Protection against damage and disease is an important function of management, and the health of the forest is one index of its success.

In America, experience of forest culture is still comparatively slight, and the problems of disease as related thereto are only beginning to receive attention. True, the enormous wastage from decay often exposed in the exploitation of virgin and wild timber stands has not passed unnoticed, and the lethal character of certain forest parasites has been fully recognized; yet it may be said that, with few exceptions, the true potentialities of pathogenic agents in the forest are largely unknown, and that the signifi-

cance of forest diseases to the problem of forest management based on sustained yield is generally unappreciated.

Forest pathological science should contribute much to the development of forestry through its influence on silviculture, regulation, and protection; and perhaps the most useful service which the forest pathologist can render to forestry is so to relate his special knowledge to these sciences that forest management may be directed in the most enlightened way.

The folowing paper has been prepared with this thought in mind. It is the result of studies of the fungus *Trametes Pini* and the disease which it causes in white pine, and embodies a review of the literature pertinent to the subject, and the results of original work. The latter derives mainly from observations in pine forests in the Province of Ontario.

2. IMPORTANT LITERATURE

While in the aggregate there is a considerable bulk of literature relating to the fungus *Trametes Pini*, important papers on the subject of the disease which it causes are comparatively few. Of these many deal mainly with the pathological anatomy of the hosts; studies of the disease in relation to silvics or silviculture are rare.

Among the works on the pathological anatomy, Hartig's exposition (13) (14) stands first. His classical presentation of the subject is still the outstanding one. We are also indebted to him for certain investigations of the fungus in the forest. Möller's researches and series of publications (30, 31, 32) constitute the most extensive general investigation of this subject. They provoked wide interest among German foresters, and have had a considerable effect on the management of pine forests in Germany, as recently echoed in a paper by Röhrig (38). Hole (16) has given an excellent account of *Trametes Pini* in Indian forests. In America, von Schrenk (40) studied the disease in New England, and Abbott (1) has contributed an important monograph with special reference to the state of Vermont. Weir (46) studied the disease in jack pine in the Lake States, and Long (21) has given an account of the decay in western yellow pine. Boyce (2, 3, 4) and Weir and Hubert (48, 49, 50, 51) have made investigations of this and other rots in virgin forests of the western United States. Percival (37) and Owens (35) (36) have recently contributed important papers on the biology of the fungus.

3. NAMES

The fruiting bodies of *Trametes Pini* are commonly known to woodsmen in Ontario as "punks" or "conks." The former term sometimes refers particularly to what is later described herein as a "punk knot."

The rot caused by the fungus is known by various names. These, for the most part, are descriptive of certain stages or conditions of decay. Thus in Ontario decay caused by *Trametes Pini* goes under such names as "red stain", "red rot", "ring scale", "ring rot", "white pocket rot", or "pecky white rot." Actually these names are not strictly specific, since they are applied indiscriminately to decays which resemble each other more or less closely but which may be of quite different etiology. Thus "red stain" may be caused by any one of several fungi, or it may not be a pathological condition at all. On the other hand, "red stain", "red rot" and "pecky white rot" are descriptive of successive stages of the decay caused by *Trametes Pini*. In western America *Trametes Pini* is commonly known as the "ring scale fungus," and the rot itself is called "red ring rot," "ring scale," or "red rot," according to its condition, or as "conk rot" (2, 3).

For the sake of clearness it seems desirable to associate the name of the fungus with the disease caused, and the writer suggests "*Trametes Pini* disease" and "*Trametes Pini* rot" as comprehensive names which he proposes to use along with such other descriptive names as may be necessary to identify characteristic stages or conditions.

A lack of definite names is also apparent in the German and French literature. The names "Rotfäule" and "Kernfäule", although not always restricted in use to decay caused by *Trametes Pini*, are locally employed with such significance. For the ring-rot condition which the fungus often causes in pine, the names "Ring-schäle" and "Kern-schäle" are often used. The fungus itself is generally known in the pine forest districts of Germany as "Kiefernbaumschwamm," although this cognomen may mean locally the shoe-string fungus, *Armillaria mellea*, usually called "Hallimasch" or "Honigpilz." Again "Kiefernbaumschwamm" may sometimes refer to *Trametes radiciperda*, the common European root-rotting fungus of conifers. "Kiefern-Tramete" as used by Hess, and "Kieferwirrschwamm" are more precise. On spruce the fungus is commonly known as "Fichtenbaumschwamm," or more rarely "Fichten Lockerpilz."

In the French language there is no common specific name for the rot. "Pourriture rouge" has sometimes a particular significance, but the term is usually qualified by further description when precision is sought. The word "rouge" is used to describe incipient infections caused by many fungi. A peculiarly interesting example is afforded in connection with the name "sapin rouge". This is a designation used by French-speaking woodsmen in the Province of Quebec, and generally recognized by them as descriptive of a variety of *Abies balsamea* having reddish coloured heartwood. Such a condition is actually due usually to infection by *Stereum sanguinolentum* (6).

4. THE NATURE AND EXTENT OF DAMAGE CAUSED

The investigation of forest diseases and their interpretation for forestry purposes presents peculiar difficulties arising in part out of the complexity of the forest itself, its dynamic character, long persistence, and slow rate of development, and in part out of the discipline (if one may use the word) which the art of forestry imposes on nature by various means. Actually, in the virgin forest, disease plays a not unimportant, and a relatively constant, rôle, in bringing about the changes of successional development; but in the managed forest, intelligence directs development towards a desired end, and so-called natural succession exists only at the discretion of the forester. Thus the problems of disease in the forest are related to, and modified by, the aims of management. In practice the forester bases his management on expediency. Hence a broad knowledge of the character and potentialities of forest diseases under various silvical conditions is necessary for the attainment of the greatest success.

The wood-rot diseases, of which that caused by *Trametes Pini* is a particularly important example, constitute a peculiarly interesting group. The causal fungi are endemic, and almost without exception have distributions coincident with the ranges of their hosts. While there is some tendency, particularly in certain species, towards host specificity, nearly all have a wide host range, and nearly all of our important timber trees are subject to infection by several species.

The disease caused by *Trametes Pini* is known as a heart rot of the trunks of living coniferous trees. This brief characterization is perhaps as correct as can be made in such a short statement, but it is both inadequate and somewhat misleading. *Trametes Pini* is definitely a parasitic fungus, and besides destroying the heart-wood of its hosts, it actually attacks living tissues. Moreover, although most characteristically displayed in mature and overmature timber, the disease is by no means confined to such, but may be present in its early stages in very young trees. It is necessary, also, to admit a modification of the conception of *Trametes Pini* as almost exclusively a trunk-rotting fungus; for we know that early infection commonly results in a typical rot in the bases of young white pines, and that the fungus is often the primary cause of what has been a very puzzling butt rot of old trees, the complete etiology of which is still unknown.

The disease is characteristically non-lethal, chronic, and slow of development. Its destructiveness, therefore, is dependent not only on the incidence of infection (rate of occurrence) but on the age at which infection occurs, and on the length of life of the host. In the natural forest the

disease will finally appear in its most advanced stage. Under continuously uniform conditions it is truly endemic, but in the white pine forests of Ontario, on account of the varying circumstances of their origin and persistence, the disease shows certain epidemic characters. The damage caused consists obviously in the destruction or deterioration of accumulated wood. The extent of damage through decay within the individual may be such as to render the tree attacked practically worthless. Thus when a stand of timber has been heavily infected for a long time, its value may be so reduced on account of rot as to prejudice its merchantability. There are available considerable data with respect to the static assessment of damage on account of *Trametes Pini* disease, to which references are given in this paper. For the white pine I have given original data derived from certain measurements described herein.

In addition to the losses which materialize as cull and degrade in the exploitation of the stands, minor damage occurs during stand development. The direct killing of trees is a rare but not unknown occurrence. Instances of windthrow and wind breakage as a result of the weakening of butt or stem are more frequent, though relatively less common than in the case of certain other rots. Much loss due to breakages in felling, however, must be charged against this disease.

One other damaging influence should be mentioned, namely, the reported effect of the disease on seed productivity. Willis and Hofmann (52) found that Douglas fir trees, seriously affected by *Trametes Pini* heart rot, produced only fifty-four per cent of a full seed crop. They consider it necessary for regeneration, therefore, that more seed trees should be retained than the usual allotment if defective trees are being designated for that purpose. Whether or not white pine is affected similarly to Douglas fir has not been discovered.

The extent to which timber may suffer through the *Trametes Pini* rot is well illustrated by the ravages of the disease in the virgin forests of western North America. In old Douglas fir in the Pacific North West, Boyce (2) found that a twenty per cent loss in volume of merchantable wood was general, and that most of it was due to *Trametes Pini*. Again, in the course of a more extensive investigation (3), he found that in certain stands, the cull amounted to fifty per cent or more, and that it was very commonly as much as twenty per cent. For the white pine of northern Idaho, Weir and Hubert (50) estimate that of the total volume of wood, approximately seven per cent is lost through decay. In individual stands the proportion is often very much greater. *Trametes Pini* is the cause of most of the loss.

The wide host range of the fungus has already been mentioned. For many of the trees attacked, no other wood rotting fungus is as destructive. Weir and Hubert (50), in Idaho and Montana, found it to be the worst enemy of the white pine, yellow pine, lodgepole pine, larch, and Engelmann spruce, the second worst of Douglas fir, and third of the red cedar. For the Pacific North-west, Boyce (2) found it the worst in Douglas fir, Sitka spruce, Engelmann spruce and white pine, and the second worst in larch.

In India, Mayes (23) has noted the destructiveness of the fungus in forests of blue pine (*Pinus excelsa*) in Simla, Punjab. In certain stands the incidence of infection amounted to forty per cent of the trees, and even pole stands only forty years of age suffered to the extent of having over a third of their stems obviously infected, as indicated by the presence of sporophores. Suri (44) reports a high rate of infection in deodar in the Baspa valley, Bushahr,—a tree which had been considered immune, or highly resistant. Hole (16) considers the fungus a serious threat to the production of coniferous timber (especially of *Pinus excelsa*) in many Indian forest districts.

In Europe, *Trametes Pini* is well known as the most destructive fungus of its kind in Scots pine, larch, and in spruce in certain districts. Gernlein (10) has described it as causing enormous damage in old pine stands, and as being a greater enemy of the forest than the worst insect pests. In certain cuttings which he studied, over thirty per cent of the trees were infected, and over thirty per cent of their wood was classed in the lowest grade on account of rot. Of the "sound wood" from infected trees, only thirty-eight per cent could be classed in the better grades, whereas in uninfected trees eighty-three per cent was so classed. On other sample areas the incidence of infection was equally high or higher. These data were considered representative of the condition of the older stands in many forest districts.

Thus we cannot assume that serious losses occur only in virgin or wild forests. Möller's (30) (31) extensive enquiries into the condition of the pine stands throughout 400 state forest districts of Germany revealed a surprisingly bad situation. Of 335 satisfactory replies to his questionnaire on the extent of infection and damage, 285 indicated that there were serious losses from *Trametes Pini* in all large cuttings. In the "best operations" in those districts, it was usual to find up to ten per cent of the trees infected; and in the "worst operations," from fifty to sixty per cent, and occasionally one hundred per cent. It was estimated that in those districts where *Trametes Pini* was common, 8.34 per cent of the timber cut was lost or seriously deteriorated.

Liese (18) recently listed *Trametes Pini* as the most destructive wood-rotting fungus of the pine (*P. sylvestris*). He states, however, that through constant care of pine stands in German forests, trunk rots have become less serious than formerly (19). But that the control of *Trametes Pini* is still a major problem in the management of pine forests in many districts in eastern Germany would appear to be the case, according to a recent paper by Röhrig (38). Röhrig regards the fungus as a serious threat to the successful management of pine for high quality timber production, and considers that effective control of the disease is called for.

In Ontario, and doubtless throughout the range of eastern white pine, *Trametes Pini* is notoriously the most destructive of the wood-rotting fungi of that species. The same may be said of red pine, jack pine, and at least locally of spruce. Data on the amount of damage accruing on account of *Trametes Pini* in old stands of white pine in northern Ontario were collected by the writer in the course of the examination of trees felled at several localities. These localities, and a description of the forest stands in which the studies were made, are given below.

At Ranger Lake and Little Garden River

Ranger Lake is in the district of Algoma, Ontario, some forty-five miles north of Sault Ste. Marie. Until a few years ago the region was difficult of access, and except for recent cuttings of pine on small areas adjacent to the lake, the forest in the vicinity has retained its virgin character. The types are representative of the main forest region designated by Sharpe and Brodie (42) as the Algoma extension; and occurrences of the regional hardwood and coniferous climaxes are to be found wherever fire has allowed the constant formative influences to exercise their maturing effect uninterruptedly. The curious disposition of the soils accounts for the constant relationship between topography and climax type. Pine stands, which are common, have attained a great age in many localities, and are clearly transitional.

A number of trees inland from the south shore of Ranger Lake, components of an old stand of mixed wood, characteristic of the slopes, were cut for examination. These trees ranged in age from 152 to 350 years, and doubtless represent the survivors of more than one establishment. On the Little Garden River, some distance to the west of the lake, a number of trees were cut in a fairly uniform pine stand, which was established some 240 years ago.

At Camp No. 28 Carpenter-Hixon Company

This locality, situated in township 3E, Algoma, and the following, lie in the same forest region as Ranger Lake, and the main forest features of

each are much alike. The stand in which studies were made was doubtless at one time of heavy pine; but with increasing age, through the action of decay and wind, the transformation to mixed wood and hardwood goes on. At present, pines up to 425 years of age are to be found standing. There are many dead-topped trees and standing chicots, as well as numerous huge trunks on the ground in various stages of decay. While yellow birch is becoming the dominant species, balsam fir up to 14" D.B.H. is not uncommon. Spruces are rare. The pine of this stand represents the oldest establishment of that species which the writer knows.

At Camp No. 26 Carpenter-Hixon Company

This stand lies on the east side of the Mississaga River, between the Wenebegon and Aubrey Falls, in Townships 3E and 4D, Algoma. It is of white and red pine, the latter species forming about ten per cent numerically of the whole. It is rather uniform, having originated some 225 years ago after a severe fire which destroyed the parent stand, at that time 175 or 200 years of age. The pine to be found to-day in the vicinity of Camp No. 28 is a relic of this ancient stand. The site is one which would ultimately develop the balsam-spruce coniferous climax, being on the gravelly soil of a river bench. Those species are abundant as an understory.

At Camp No. 2 J. R. Booth Company

Situated at the northwest end of My Kiss Lake, Township of Preston, in Algonquin Park, Ontario, this locality, as well as the following, lies within the Ottawa-Huron forest region (42), a region which resembles silvically the Algoma Extension, already referred to. The edaphic features of the forests here, as exhibited by type segregation topographically, are perhaps not as obvious, since there is less uniformity in the disposition of soils. There are, moreover, additional tree species in comparative abundance, including beech, basswood and hemlock. On the other hand, jack pine, which is common in Algoma, occurs here only locally.

Camp No. 2 was situated on a gravelly bench slightly above the lake, in a region which, except for the removal of a number of the largest trees for square timber some forty years ago, was covered with virgin pine forest. Most of the trees ranged in age from 250 to 300 years. Considerable windfall had occurred, but close to the lake the stand of pine was still very heavy.

At Camp No. 3 J. R. Booth Company

This locality is in the Township of Preston, Algonquin Park, one mile northeast of the outlet of MacDougall Lake on the Opeongo River. While the camp itself was situated on the river flat, the stand in which the work was conducted was at a distance to the north, in the mixed woods on the slopes of the high though not precipitous hills. Towards the tops of the hills, hardwoods dominated, except on the rocky outcrops where pine of inferior development held its own. The present stand of pine originated after a fire 150 years ago which destroyed the parent trees, except a few individuals of large size which still remain standing. These evidently are of the same age, and were once doubtless co-extensive with the stand now occupying the ground at Camp No. 3.

For the volumetric studies of rots in the large timber at Ranger Lake and Little Garden River, selected trees were felled and examined thoroughly to determine the character and extent of the rots present, and particularly to develop standards for estimating rot in the log, by measurement and inspection. The procedure was to cut the tree as close to the ground as possible, expose all the roots for a distance of 6 to 8 feet from the stump (or farther), chop through them, split the stump if necessary, or remove it intact in order to examine the base. The trunks were cut at about breast height, again at 8 feet, and successively at eight foot intervals throughout their lengths, or closer if deemed necessary. Many sections were split longitudinally. These careful and laborious examinations were made primarily in order to discover the common root and butt rots of pine, and to measure the rot volumes in the trunks and determine their form.

At the camps of the Carpenter-Hixon Company and the J. R. Booth Company, the trees were examined as felled by the logging crews; and measurement or estimates were made of the rot in the logs, which were cut 12, 14 and 16 feet. In the case of cull logs, additional cutting was sometimes done, and occasionally the roots of trees were exposed and examined.

The rots have been classified as *Trametes Pini* rot (TP), cavity rot which is often initiated by *Trametes Pini* (C.R.), a butt rot of old trees, and "other rots." Dead cull logs are those which are considered worthless by the lumberman, and consequently are not skidded. Volumes of trunks felled but not bucked are of course included in this category. The culling of logs varies according to judgment as to what may be extracted profitably and is dependent on the cost of transportation to the mill, as well as on the amount of the sound wood in the log. In practice it varies considerably. Thus the culling of logs in the J. R. Booth operations was rather more severe than in those of the Carpenter-Hixon Company. If the dead cull

logs represent no asset, their volume should not be included in estimates of standing timber. The "cruise cull" factor of the tables, therefore, includes the total rot volume plus the volume of sound wood in dead cull logs.

For the measurements, the total volume of each log was calculated by the Smalian formula, allowance being made in butts for flare. The volume of the rot in each log was calculated from measurements of basal area, and measurements or estimates of length and form. By definition, "rot" included such wood as showed "red rot", "white pocket rot," or worse, due to *Trametes Pini*, or their equivalent, from the standpoint of utilization, in other rots. Basal areas were outlined to include the rot in simple geometric forms. The volume of the tree from the stump to the actual top cut was found by summing the volumes of the component logs. The volume of rot of each kind for the whole tree was also found from the summation of rot volumes in each log. The data for dead cull logs were retained separately.

Tables 7, 8, 9 and 10 summarize the data from these measurements.

In Camp No. 3 J. R. Booth Company, 49 per cent of the trees examined had *Trametes Pini* trunk rot, and 33 per cent of them cavity rot. This was a comparatively young stand, originating approximately 150 years ago. The rot volume amounted to 9.9 per cent of the total volume of the trees, 6.3 per cent being due to *Trametes Pini*. The cruise cull amounted to 17.8 per cent.

In Camp No. 26, Carpenter-Hixon Company, in pine from 200 to 225 years old, 60 per cent of the trees cut had *Trametes Pini* trunk rot, and 48 per cent cavity rot. The rot volume amounted to over 16 per cent of the total volume, nearly all of it due to *Trametes Pini*. The cruise cull amounted to nearly a quarter of the cut.

At Camp No. 2, J. R. Booth Company, in pine which ranged in age from 250 to 300 years, 81 per cent of the trees had *Trametes Pini* trunk rot, and 54 per cent had cavity rot, accounting for a loss of 20 per cent of the total volume. The volume of all rots amounted to 25.8 per cent, and the gross loss (cruise cull) to 45 per cent.

Of the small number of trees cut at Ranger Lake, all were affected by *Trametes Pini* trunk rot, and three-quarters of them by cavity rot, causing a volume loss of 19.3 per cent. Other rots brought this loss to 27.3 per cent, and it was estimated that the gross loss (cruise cull) would be practically 50 per cent.

At Camp No. 28 of the Carpenter-Hixon Company, in a stand with individual pines over 400 years old, 81 per cent of the trees had *Trametes Pini* trunk rot, and 94 per cent had cavity rot. In the trees examined there

was a loss on this account of 22.4 per cent, which with other rots amounted to 28.7 per cent. The gross loss (cruise cull) was 43.1 per cent.

A statement of the amount of rot in old standing timber does not give a true picture of the total damage caused by the disease in the stand, however, for windfalls have been neglected. It is doubtless true that the surviving trees are, in general, those in which decay has made least progress. In very old, defective pine stands the number of trees on the ground may be as great as the number standing. Such was the case at Camp No. 28, Carpenter-Hixon Company, where many logs were being made from trunks that had been windthrown years ago. While the butt- and root-rotting fungi are of greater importance than is *Trametes Pini* in bringing about the wind-fall of pines, the latter undoubtedly contributes to it.

5. THE SYMPTOMS

The presence of *Trametes Pini* disease is indicated by a number of gross signs and symptoms, including the presence of the fungus fructifications and mycelia, localized swelling of the host as a result of abnormal growth, resin flow, "punk knots" more or less extensive surface lesions, "bull grain," and a depauperate condition of the foliage and stagnation of growth, indicative of starvation. One may add hollowness of the trunk, as indicated by sounding, and the various rot conditions of the wood.

Fructifications and Mycelia

The fructifications of *Trametes Pini* are extremely variable. The largest specimen which the writer has seen, measuring 15″ x 19.5″ x 5″, was collected by Dr. G. D. Darker, near Government Camp, Oregon, on living *Tsuga heterophylla*. (No. 2865 Herb. G. D. Darker. No. 360, Pathological Herbarium Arnold Arb.). Fructifications of this size are doubtless rare, yet in western forests, particularly on Douglas fir and hemlock, they grow commonly to sizes rarely seen in the east. On eastern white pine, fructifications an inch or two in diameter are the commonest, and many may be found no larger than a quarter by half an inch. Some of these small fruit bodies grow larger; others do not and many perish after casting spores for but a single season.

As to shape and habit, the variations include ungulate, dimidiate, conchate, imbricate, and effuso-reflexed types. It should be said that although the environment and particularly the nature of the substratum exert a strong influence in determining the character of the mature fructification, all differences thereof are not to be explained in that way. It is apparent that there exist in nature mycelia of this species which differ constitution-

ally. Such have been recognized by Owens (35) (36) in western American forests. My own collections of the fungus from eastern white pine have yielded cultures which differed markedly among themselves. It should be noted, however, that fructifications often intergrade, and that none are constantly characteristic of a particular mycelium. Thus Overholds (34) reports the finding of numerous sporophores of *Trametes Pini* mingled on the same spruce stub with those of *Trametes piceinus*; all, presumably, coming from the same mycelium. Similarly, I have repeatedly found on fallen white pine typical ungulate, hard fructifications of *Trametes Pini,* formed while the tree was standing, and immediately adjacent typical thin, reflexed almost resupinate fruit bodies of *Trametes piceinus* formed after the trunk had fallen. Generally speaking, fructifications on the under-surface of trunks and logs on the ground are of the effuso-reflexed type; those on standing dead trees are usually delicate, conchate or effuso-imbricate; none of these are long persistent, though they may show revival and overgrowth, or partial overgrowth, for several years. The long persistent, ungulate, *Fomes*-like fructifications are those that develop slowly on a living host. These forms are commonly formed only on certain host species. They occur on white pine and particularly on the hard pines. Rarely if ever are they found on spruce.

All sporophores show certain structural and colour zonations, which correspond with periodic growth. Many old ones doubtless exhibit annual zonation, although the positive determination of the age of specimens is difficult,, if not impossible. The zonation observable in young fruit bodies is the result of unequal seasonal growth, rapid growth taking place during periods of wet weather. The writer has occasionally marked the growth of a single day; and where diurnal and nocturnal temperatures vary extremely, fine daily zones are discernible within the broader belt.

In *Trametes Pini* the porous layer is organized consistently as rounded pores, or in configurations varying from rounded pores to labyrinthine or daedaloid channels. No habit type of fructification (ungulate, conchate, etc.) is characterized by a particular kind of pore structure. For example an ungulate type common on living, old field pines, has extremely small, rounded, thick-walled pores. The ungulate type on Douglas firs usually has daedaloid or labryinthine pores. On spruces in Ontario we find effuso-reflexed types with small round pores and others with lacerate sub-daedaloid pores. Fructifications on northern Ontario white pines vary greatly, but usually their pores are rather large and thin-walled.

In perennial fructifications the pore layers are rarely distinct—certainly not "as distinct as in any other *Fomes*" (Lloyd (20)). Where overgrowth of the old surface from the base or elsewhere occurs, as often happens, a

distinct new stratum may be formed. But when growth is resumed uniformly from the extremities of the trama of the previous season, no distinct demarcation can be seen. The pores, of whatever shape, begin to fill with a delicate woolly stuffing early in the fall of the current season. By the end of the following season it becomes so compact that it can scarcely be distinguished from the tissue of the trama and context.

Setae, somewhat irregularly scattered in the hymenium, are usually abundant and just visible with a hand lens. In rapidly growing fructifications, they are not found close to the mouths of the pores. They are large and thick-walled, but their cavity is continuous almost to the tip, and expands somewhat just above the base. The base occasionally extends a short distance into the trama as a thick-walled hypha. Typically they are narrowly conical in shape, with the base somewhat rounded; but irregular shapes occur. In length they measure 35-60 u, and in greatest diameter 7-10 u.

The spores (of which basidiospores only are known) are exceedingly delicate when freshly cast, and on immediate removal from water collapse on drying. The wall is barely distinguishable at first, but appears to thicken slightly as the spore ages, and it acquires a pale yellowish colour.

Very poor germination in van Tieghem cells has characterized the tests which the writer has made with spores dispersed in drops of tap water, distilled water, or pine wood decoction. It is interesting to note that some spores germinated in white pine resin taken from a stump. The drying on the slide of fresh spores beginning to germinate, often destroys them. Under observation, as the drop dries, the spores and germ tubes may fragment. Adding water has failed to revive them, the smallest fragments, on the contrary, disappearing. But even the moisture of the breath revives the drying spores and germ tubes, if the desiccation has not been too prolonged.

The best germination was obtained on the surface of an agar such as potato-dextrose on malt agar. Percival (37) tested various agars as substrata for the germination of spores, and found many suitable. For early and high rates of germination he suggests that readily available sugars, especially maltose, are favourable. Of considerable importance too, is the pH concentration of the substratum. It would seem that the optimum value lies between 5 and 6, and that the range which is favourable is rather restricted.

The mycelium of the fungus, both in culture and in the host, consists of thick-walled and thin-walled hyphae, with forms more or less intermediate and variant. Young hyphae are thin-walled, essentially hyaline and readily stainable with picro-aniline blue. These hyphae are mostly

cylindrical, 1-3 u in diameter, occasionally much finer, rather sparingly branched, septate and without clamp connections. Extremely find threads have been observed in old cultures and in the substance of "punk knots." The walls of the hyphae appear to thicken gradually with age. Occasionally there is an abrupt change from a thin-walled hypha to a thick-walled one on the other side of a septum. The walls of the thick-walled hyphae are hard, brittle, brownish-yellow and sometimes finely pitted or nodose. No septa are visible in such hyphae, and they do not stain with picro-aniline blue. They often show irregular shapes and terminal or intercalary swellings, singly or in chains. Anastomoses may occur, resulting in sclerotioid or spore-like bodies. A helicoid growth has frequently been observed in the aerial mycelium of old cultures. Descriptions of the mycelium and mycelial mats on various media are given by Fritz (7).

The presence of fructifications is a positive indication of *Trametes Pini* rot in a moderately advanced to severe form. Unfortunately for diagnosis many infected trees rarely bear them. On a living pine, they appear only where dead wood is exposed, or where a connection is maintained by the fungus with the dead wood of the tree. Thus they are found springing from wounds extending to the heart wood and from the surface of dead sapwood, when such is contiguous with heart wood. The commonest locus is at a branch stub. Here they may arise directly from the wood of the dead branch—a condition which is comparatively rare in dense stands with well formed trees, but common enough among open-grown, branchy trees exposing large areas of wood at the stubs. The sporophore, when based on a stub, usually emerges directly from its transverse face; and the shorter the stub, the more favourable is the chance of sporophore formation. More rarely it springs from a knot in the dead branch. This has been observed when large dead branches have been retained whose outer wood near the trunk was deeply infiltrated with resin. Whenever emergence is from dead wood, no "punk knot" is formed there. Many sporophores however are based on stubs long since buried by the growth in diameter of the trunk. In such instances they are attached to the bark but maintain a connection with the heart of the tree through a "punk knot" and the remnants of the buried stub. Occasionally, in white pine, sporophores spring directly from the bark of decrepit trees; and in such cases countless numbers may develop within a single season over many square feet of bark.

Swelling—Swelling occurs in the host as a result of abnormal, largely hyperplastic growth induced by the fungus when in or near meristematic tissue. It is usually localized around branch stubs and is associated with the formation of "punk knots." Swelling is commonly found around knots at the same whorl, or at those located vertically above one another.

Resin Flow—A flow of resin is a symptom of considerable diagnostic value and is often a valuable aid in early diagnosis. The flow from vigorously developing "punk knots" is often copious, long streaks of hard or soft gum extending downwards from the source. A more or less moderate flow often arises from covered knots, bases of stubs and open knots showing no punkiness, but in the vicinity of trunk infections. Again, there is often a slight flow of resin from trees which otherwise appear to be perfectly healthy. Yet other trees, particularly older, slow-growing trees, in which the rot is well developed, may show no flow at all.

"Punk Knot"—A "punk knot" is perhaps the most interesting and characteristic symptom of *Trametes Pini* disease. It is formed as a result of chronic infection of the phloem and periderm of the trunk and the stimulation of the cambium in the immediate vicinity of a branch stub.

A mature "punk knot" consists of a mass of rather tough to friable brownish substance extending from the remnants of a stub often well within the trunk, to the exterior. It is somewhat conical in form, varying from an approach to the shape of the frustrum of a paraboloid to that of a neiloid. In transverse section it is symmetrical, usually slightly oval, with its long axis in the vertical plane. Its rate of taper varies greatly. Young "punk knots" are compact and solid with relatively little taper, and may enclose the stub. Old ones and those developing on older trees are often expansive and often somewhat hollow, forming a punk cavity rather than a solid core. The stub may be buried long since.

In young trees, in the absence of resin flow and conspicuous swelling, it is often difficult to detect a "punk knot" externally. Careful examination by scraping the overlying bark will, however, usually reveal its brownish fungus substance; and an axe blaze serves to expose its transverse section very clearly. (Fig. 3).

Surface lesions—Extensive surface lesions are sometimes found on trees in which the disease has reached an acute stage. As already indicated the fungus ordinarily affects the cambial meristems in the immediate vicinity of branch stubs. Occasionally from such centres the fungus spreads laterally, involving large areas of the contiguous bark and outer wood. Such lesions show extraordinary pathological conditions and reveal the fungus in a very definitely parasitic rôle. These conditions include the formation of resin in large cysts on the face of the wood or in cavities of necrotic origin, and the development of "bull grain" in adjacent wood. In dying trees the fungus penetrates the sapwood from beneath, and reaching the surface of the wood passes through the bark and fruits there freely either before or after the death of the trees. (Fig. 4).

"Bull Grain"—"Bull grain" is a term used to describe wood which

shows certain marked abnormalities induced by the fungus during the maturation of its cells. The appearance of freshly exposed "bull-grained" wood is somewhat similar to that of burl veneer. This appearance is due to a curious tough-textured interweaving of the tissues of the xylem. Besides the distortion of the grain, such wood is distinguished by the presence of abnormally numerous and conspicuous resin canals, with which much parenchymatous tissue is associated. Small areas of "bull grain" are commonly found around "punk knots," but occasionally large surfaces of the trunk become involved. "Bull grain" does not usually extend centripetally to any great depth; but I have found it to comprise as many as twenty-five narrow annual rings.

Hollowness—Hollowness of the trunk occurs occasionally at stump levels as has been noted above. This can so be detected sometimes by "sounding" with an axe.

6. PATHOLOGICAL HISTOLOGY

The pathological histology of infected Scots pine wood has been admirably described by Hartig (14) and of spruce by von Schrenk (41). Therefore, in presenting this phase of the subject with reference to white pine, I shall deal only with what is essentially new material, namely, evidence of the parasitism of *Trametes Pini* and such relevant destructive action of this organism in white pine as has not been adequately treated elsewhere. Evidence of parasitism of *Trametes Pini* in white pine is found in the phenomena associated with "punk knot," "bull grain," and invaded sapwood.

A "punk knot" (Plate 1, fig. 3) is a pathological structure, the result of chronic infection in the vicinity of cambial meristems. It is thus indicative of parasitism, and is actually developed only on a living tree. Such infections are not isolated, but are continuous with infection in the trunk and are apparently dependent thereon for initiation. The fungus, emerging from the heartwood through the sleeve of resinous debris surrounding a dead stub becomes established in the outer bark of the trunk, with which the sleeve is continuous, and maintains itself there, apparently in an effort to fruit.

The "punk knot" substance is composed of fungus hyphae together with necrotic host tissue which is gradually consumed. The central part or core consists largely of tangled yellow hyphae with some hyaline threads intermingled, in which may be embedded fragments of dead bark or farther inwards of wood of the branch stub. Peripherally to the core at the distal part of the "punk knot," are to be found islands of tissues in various stages of destruction, in a matrix of tangled fungus hyphae of the usual type, and

in addition bulbous and sclerotioid hyphal elements. This tissue is derived from the cambium and living phloem. At the margin of the "punk knot," the region of invasion, the living phloem is conspicuously thick and spongy. Rays are large and numerous and resin production is copious. The influence of the fungus is apparently stimulative, though finally lethal. In this region wedges of compacted bulbous elements of the fungus, of both thick- and thin-walled types, and small almost amorphous masses or tongues composed of fine hyaline hyphae occur, and such appear to be the invasive agents in the living phloem. More or less organized mycelial formations also occur in the dead bark. That the cambium is actually invaded was proved by the examination of a "punk knot" specimen collected late in the fall. Hyphae were detected among the last formed cells of the wood, apparently the cause of a slight separation of these elements. In the proximate phloem, which was remarkably disturbed, there were a few isolated and disoriented tracheids.

"Bull grain" wood derives its character as a result of abnormal growth of the xylem. It has been found only in instances of severe trunk infections, and in association with punk knots. The tracheids of such wood are shorter and thicker and have more pits than is normal, particularly in their tangential walls. Their direction of elongation varies and is not common even among neighbouring cells. The tissues do not display their normal symmetry, a result of disturbance of the normal polarity of the growing cells. In the vicinity of resin canals it is not uncommon to find tracheary elements which have segmented (Plate 1, figs. 10, 12). These seem often to have died prematurely, as indicated by the occurrence of residues of protoplasm and encrustations within. A feature of considerable interest is the occurrence of inflated ray cells and of tyloses in tracheids of such wood. Many ray cells exhibit this tendency to inflate, and in some instances the nucleus passes into the inflated part. (Plate 1, fig. 10). Instances of considerable extension of tyloses in tracheids were observed. (Plate 1, figs. 11, 12). In "bull grain" wood, hyphae have been detected in contact with living epithelial cells surrounding resin canals. Such hyphae were hyaline, rather fine and sparsely distributed. Irregular thick-walled sclerotioid hyphal elements were observed in adjacent dead or dying cells. At the periphery of "punk knots," I have observed infection of the cambial region, and the invasion intra- and intercellularly of the late wood of the current season. Such infections are apparently the cause of a local development of "bull grain" in the wood of the following spring. Small isolated patches of "bull grain" have been observed in the spring wood of five consecutive rings, the last of which (that of the current season) exhibited infection of the late summer wood and cambium.

Whether or not the fungus invades normal sapwood from an underlying heart infection is a question on which there have been differences of opinion. Hartig held at first that only heartwood was susceptible, though later he admitted that "functionless" sapwood also was susceptible. Von Schrenk (41) stated that hyphae enter the sapwood of spruce, hemlock, fir and larch, but not of pine." Percival (28) did not find the fungus in the living sapwood of infected spruce, though in wood only eleven years old he detected hyphae approaching within two annual rings of nucleated parenchyma cells. Nevertheless he regards the fungus as a saprophyte in spruce.

The present writer has never found hyphae from beneath coming in actual contact with living cells in normal sapwood. But everywhere there seems to be action in advance, resulting in death of cells a short distance removed from the mycelia In instances of severe trunk infections in white pine, it can hardly be doubted that the sapwood dies prematurely and is invaded by the fungus. The writer has seen infected trees in which the white living sapwood was reduced to an exceedingly thin sheath, in places scarcely more than a millimetre thick. Wood immediately beneath this zone becomes slightly pinkish orange in colour, resembling heart wood. It is apparent, however, that it is pathological. In such wood the epithelia of the large vertical resin canals still contain living cells, but many have died or are dying and enclose drops of "wound gum" or lumps of yellowish decomposition products. The walls of such cells are pale yellow or brownish in colour. The epithelial cells of horizontal resin canals are among the first to show these changes. Bordering this zone inwards there is dark, reddish, resinous wood, in which only a few nucleated parenchyma cells are to be found and these are obviously dying. Here hyphae of the fungus occur in profusion, not uniformly distributed, but thickly congregated in some areas and scarce or absent in others. Ray parenchyma cells seem to be particularly favoured, though many tracheids are almost plugged with hyphae. Hyphae occurring in this zone, in cells that appeared to have died only recently, were observed approaching within 0.5 mm. of living parenchyma and were only 2mm. from the cambium.

In view of the regular occurrence of "punk knot," the development of "bull grain" in wood and the constant association of pathological conditions peripherally with heavy infection in the heart, it is reasonable to conclude that *Trametes Pini* is parasitic on white pine.

7. FORM AND CHARACTER OF THE ROT

Trametes Pini rot is either of the butt or bole of the tree. Isolated infections occur occasionally in the larger limbs of old trees, which infec-

tions develop within a more restricted locus similarly to those within the trunk.

The butt rot commonly found in old trees, usually originates as a branch stub infection when the tree is comparatively young, and passes through stages which are typical of the rot in the trunk, until in time the fungus dies out, and the decayed part is colonized by other fungi, which modify to some extent the original character of the rot. To this rot the distinctive name of "cavity rot" is given. "Cavity rot" is typical in form, extending upwards and downwards from the point of greatest diameter in the stump, as cones on a common base. The upward extension is considerably greater than the lower, which ends blindly in the base of the stump, or penetrates large roots a short distance. The rot extends to a height of three to six feet, occasionally more in large trees. Its centre is hollow, or partly filled with delaminated and fragmented wood, a mass of material which resembles somewhat wood in the advanced *Trametes Pini* rot condition as found in trunks. Beyond this central part is a zone of honey-combed wood, which shows pocketing in an advanced stage. This zone ends rather abruptly in a pinkish border and passes sharply into the sound wood.

In old white pine trees it is unusual to find external symptoms of "cavity rot." In studying this rot, many cultures were made from affected wood in the stumps, but it was only rarely that *Trametes Pini* was isolated. It is clear that the fungus dies out in the butt when the trees reach an advanced age. This is confirmed by the finding of dead and completely buried "punk knots" in the butts of a few old trees whose stumps were examined very thoroughly. Non-progressive basal infections, with practically stagnant "punk knots" were found in many trees approaching 200 years of age.

What is apparently the same kind of butt rot has been noted by Weir and Hubert (50) in western white pine. Boyce (3) states that in this species red ring rot caused by *Trametes Pini* is commonly confined to the butt or first log. A study of *Trametes Pini* in young stands of western white pine would doubtless show that, as in the case of the eastern species, these infections originate at an early age, and assume the distinctive character of "cavity rot" only when the tree has become old.

The rot in the trunk exhibits itself according to its state of development as red stain, red rot, white pocket rot, or advanced *Trametes Pini* rot. In form or shape the rot assumes the character of ring rot or ring shake, finger or streak rot, or uniform rot.

Red stain is found at the margins of all infections, and in individuals may involve large volumes of wood. Wide-ringed and branchy trees show a preponderance of red stain and red rot, due, probably, to the comparatively

rapid growth of the fungus in such trees. White pocket rot is more conspicuously characteristic of some other species than it is of white pine, but it is often well displayed, particularly in large trees in which the rot is uniform in type. In advanced rot the characteristic white pockets have disappeared, and the wood has become honey-combed and somewhat friable.

The form which the rot takes in the bole is dependent in part on the manner of infection. Early infection, above the butt, through small branch stubs, usually leads to its development uniformly in the heart, when the tree reaches large size. Infections through wood near the periphery of large stubs develop in an eccentric position in the bole, and tend frequently to follow the course of one or a few annual rings, leading to ring rot. Finger rot originates similarly, or from basal infections, the fungus growing up into the bole through rather restricted volumes of wood. It appears on the ends of logs as irregular patches, and in boards as streaks or fingers of decayed wood. The extremities of rot, which is uniform in the central part, are often of the finger type.

8. The Detection of Infected Trees

The identification of infected trees in the forest is a matter of practical importance in timber estimating or for disease control. Düesberg (5) in Germany, referring to the making of sanitation thinnings in pole stands of Scots pine, says that skilled men are highly successful in detecting infected trees on the basis of "punk knot" symptoms alone. Boyce (4) claims that it is easy to detect living Douglas firs affected with *Trametes Pini* rot, and that it is even possible to make reasonably good estimates of the amount of rot in standing trees. A more difficult problem in this connection exists with respect to white pine in eastern America.

The identification of infected trees is dependent on ability to detect specific symptoms, and for practical purposes, examination must be made from the ground. The symptoms associated with "general appearance" referred to by Abbott (1) are not at all specific, and are exhibited only in the most advanced stages of this disease. The symptoms of practical use for diagnosis are the presence of fruit bodies, "punk knot" and the associated swelling, and resin flow. Hollowness, as indicated by sounding, is sometimes useful. The condition of borings taken from the trunk is often helpful in diagnosis, but this examination is laborious, and only the lower part of the trunk is easily accessible.

Although often rare in white pine, as pointed out in the section of this paper dealing with the fruiting habits of the fungus, the occurrence of sporophores is one of the most useful indications of the presence and extent of rot in stands. But many affected trees are without sporophores and, if

present, the latter are often of such small size and so well hidden from an observer on the ground as to pass unnoticed. Yet the rate of occurrence and position of sporophores, in the light of knowledge of the age of the stand, helps greatly in estimating cull. Fructifications are most abundant when a certain stage of development of the disease has been attained. Early infection of the trees contributes towards the formation of fruit bodies low down on the trunks. It is impossible to state in general at what period during the life of a stand fruit bodies will be most abundant, for this is dependent on the silvical character of the stand and on when it became infected. The rate of development of rot in the trunk is largely dependent on the character of the wood, particularly the width of ring. In Northern Ontario, under the fairly uniform growing conditions of virgin stands, where the trees have been exposed to infection from an early age, sporophores are most abundant on trees from 125 to 175 years old. On very old trees, sporophores are exceedingly rare, particularly on the lower part of the trunk.

"Punk knots" often indicate rot when sporophores are lacking. The punk substance itself can rarely be observed without chopping off the covering bark, but the pronounced swelling over the knot, with its abnormal bark fissuring and often copious resin flow, are conspicuous enough, when well developed, to be seen high on the trunk. These symptoms are most conspicuously shown by vigorous trees in which rot is well developed, during the period in which fruiting is most abundant. The normal swelling around large stubs almost covered by overgrowth is very deceiving and may easily be mistaken for a pathological symptom, when close observation is not possible. Similarly, exudation of resin from around branch stubs often occurs moderately in trees which are apparently perfectly healthy. It is by no means a specific symptom of *Trametes Pini* rot.

9. FRUITING HABITS OF *Trametes Pini* AND THEIR SIGNIFICANCE

Since the spread of *Trametes Pini* is dependent almost entirely on the dissemination of spores from the well known fructifications, the fruiting habits of the fungus are of critical importance with respect to the occurrence of the disease in the forest. From the standpoint of control, therefore, it is essential to know for any given region in which control is to be attempted, just when and where the fructifications are produced. This raised no problem for Boyce (2) in Douglas fir stands, Weir and Hubert (50) in western white pine stands, or Hole (16) in *Pinus excelsa* stands, because in them fructifications were found in great abundance on affected trees. But such experiences are not universally true, for there are regions in which *Trametes Pini* rot is common, and at the same time the fructifica-

tions of *Trametes Pini* apparently very rare. Such is the case in northern Ontario where on the vast majority of diseased pines no fructifications are to be found. The existence of this situation was suspected by the writer from casual observation in many white pine stands in the north and the inspection of thousands of newly made logs in the woods. It is proved by the careful examination of many trees.

In table No. 5a are given data on the occurrence of *Trametes Pini* fructifications on living white pine in several localities in northern Ontario. A summary statement, may be made as follows: Of 2,307 trees examined, ranging in age from 30 to 429 years, of which more than 257 were certainly infected, only 28 bore sporophores,—for the most part of very small size. Of the 30 infected trees on the plots, only 1 bore a single small fructification. At localities 2 and 3, of nearly 1,400 trees examined, only 4 bore fructifications. The incidence of infection is unknown, but assuming it to be the same as in the plots, less than 1 tree in 50 bore the fungus in fruit. Of 90 trees 88 to 150 years old examined as cut at locality 8, 44 were found badly decayed, but none bore sporophores. Of 138 trees cut in very old stands at localities 9, 10, 11 and 12, 100 were decayed, but only 3 bore sporophores. Indeed sporophores on living pine were exceedingly rare in all stands in Ontario examined by the writer except in the Little Nipissing Valley and at Tilden Lake. At the former locality of 100 trees selected at random and examined from the ground, of which at least 42 were decayed, 5 bore a total of 8 sporophores. At Tilden Lake, of 52 trees examined at least 30 of which were decayed, 12 bore a total of 19 sporophores.

It is difficult to reconcile the usual scarcity of fructifications on the trees with the heavy incidence of rot commonly found. One is led to suspect that the fungus fruits more abundantly somewhere in the forest other than on the trunks of standing pine. A number of windfalls and cull logs of pine were examined, therefore, to discover whether the fungus fruited on them, and for what period of time such material might serve as a source of inoculum. It was found that prolific crops of sporophores were produced from such infected dead wood, and that indeed, this material constituted the chief foci from which inoculum was dispersed over long periods of time. From detailed notes of field observations, the salient features of the fruiting habits of the fungus in dead wood may be summarized as follows: (1) With rare exceptions only the trunks or logs of infected trees are able to support sporophores. Whenever they have been found on branches (only in the case of spruce) the latter had not been severed from the trunk, and the rot was continuous throughout. Thus logging slash (small material) has little if any importance as a source of

inoculum. (2) Most of the fruit bodies appear on the under side of infected logs or fallen trunks especially during the first few years, and they can be discovered there only by rolling the logs over. If adequate shade exists or is established through the growth of vegetation, sporophores commonly appear on the ends of the logs, on their sides, and rarely on their upper surface. Logs exposed to direct sunlight and drying influences produce few if any sporophores. Thus those that are left on rocky terrain, or are lodged high, are likely to produce few, while those left in contact with the soil in shaded situations surrounded by vegetation are likely to produce many. (3) Sporophores issue through the bark at any part of the surface of a log, the first usually appearing in the neighbourhood of stubs or covered knots. Comparatively few issue from "punk knots", the site of nearly all sporophores found on living trees. (4) The presence of friable brown rot and other rots appears to be inimical to a vigorous development of *Trametes Pini.* (5) Fruiting on cull logs begins as early as the summer following cutting, and attains a maximum intensity within a few years, but may persist for over 20 years if the logs are large.

In mixed conifer stands windthrown spruce may harbour most of the fungus fructifications, and may be the chief source of inoculum. This was suspected at Ranger Lake, where the majority of pines were diseased, yet carried very few fungus fructifications. Windthrown pines were scarce, and none were found on the area studied intensively. Spruce, on the other hand, occurring in admixture with pine, and locally in pure stands of small size, had suffered considerably from windthrow and wind breakage, and many trunks and stubs of that host were found bearing sporophores profusely. Indeed, the most luxuriant growth of sporophores which the writer has seen was on a 14" spruce trunk which had been four years on the ground. The tree was rotted almost throughout, decay extending even into the small branches. The underside of the trunk was literally covered with fructifications of which 92 were counted, the largest an effuso-reflexed mass, measuring 14" x 4". Many small sporophores were growing on branches less than one inch in diameter. While it has not been proven that spores from a fructification of *Trametes Pini* on spruce may infect pine, there is a strong circumstantial evidence that such is the case. Although various strains of the fungus exist in nature, as shown by the cultural characters of different mycelia it is not at all certain that these are strongly host specialized.

Pine stands in northern Ontario have as a rule followed fire. Thus they grow to maturity roughly even aged, and are dependent on catastrophic change for their regeneration. If fire does not occur, there is a gradual transition to other types on most sites. In old stands, therefore,

in which the fungus has become established, there is no difficulty in explaining the occurrence of infection currently; for the fungus is to be found in fruit abundantly on fallen trees, and less commonly on those standing. But in young stands whose trees do not bear sporophores, it is impossible to account for the occurrence of rot on the basis of self-infection.

Observations by the writer at McPhee Lake, in the North Bay district of Ontario, indicate that the destruction of an old stand by fire initiates a long period of excessive fruiting by the fungus, which may persist until the reproduction has become susceptible to infection. At this locality an extensive fire had occurred 18 years earlier. The original stand had been chiefly of pine 12 to 20 inches in diameter, and from 150 to 160 years old. The fire was severe, and most of the trees had been killed. Here and there, however, individuals, or small groups survived, and some still remained green (among the more numerous standing dead trunks) at the time of examination. Windfall of dead and living trees had been continuous since the fire. A number of fallen trunks were examined for fruit bodies of *Trametes Pini*, and these were found in abundance, particularly on the more recently fallen green trees. Sporophores were found, however, on trunks which had been on the ground at least 15 years. It was clear that a grand fruiting period was still in progress throughout the area, and that it would continue for some time. Among the reproduction, the largest pines had already attained an age at which they might become infected.

The Bissetts plots (see addendum No. 1) are representative of stands which originated after a severe and widespread fire some 60 years ago. No large pines are to be found now within a distance of several miles. Fructifications of *Trametes Pini* are exceedingly rare on the trees, and it is quite certain that until recently there could have been none at all. Yet nearly 20 per cent of the trees on the plots were infected, many of the infections being of long standing.

These investigations of the fruiting of the fungus in the forest reveal a number of features of prime pathological importance. In white pine the death of the host results in an enormous increase in the abundance of fructifications of the fungus. Grand fruiting periods occur whenever large quantities of infected timber are brought to the ground, as following the destruction of an old stand by fire, or subsequent to logging operations in which much infected timber is felled and left in the woods. These periods are of long duration, and are of prime importance in the spread of the disease. They are particularly significant with respect to infection in' young stands. One is led to the conclusion that in northern Ontario the disease passes to the new stands through the agency of spores from fructifi-

cations borne on infected debris resulting from the destruction of the old. Further evidence that such transmission occurs is offered in those sections of this paper dealing with infection courts, the age at which infection occurs, and infection in relation to tree class.

10. PERIODICITY OF SPORULATION

According to my own observations, the casting of spores from the fructifications of *Trametes Pini* is characterized by fairly well-marked season periodicity, with sporulation most active in spring and fall. Thus at Petersham, Massachusetts, spore traps were continuously maintained throughout an entire year beneath protected sporophores on a living white pine and examined at intervals for spore deposit. Throughout the first summer collections were made at approximately weekly intervals, but during the winter and the following spring and summer, collections were more irregular. The vigour of sporulation was estimated comparatively in four degrees. These data are shown in Table No. 4. During the first summer, practically no sporulation took place until late August. It was greatly accelerated during the wet weather in the fall, reaching a maximum in October and November. From the end of November until April, there was a cessation of sporulation except for a revival in mid-winter (late December and early January). This was due to the influence of mild weather and rains, which thawed the sporophores and doubtless induced a cast at the expense of accumulated reserves in the fructification— a cast such as one may induce at almost any time from a freshly detached sporophore. Further sporulation did not take place till April, and it was gradually resumed after a good many days of warm weather. Next summer there was rather more activity in spore casting than during the same season of the previous year, a result which may have been incident to the greater rainfall.

Again at Achray, Ontario, during the month of September, after frosts, spore traps were set under sporophores on the side of a dead white pine trunk on the ground, and examined periodically. During the dry weather of the early part of the month, a light spore cast took place a few times at night, but it was not until after the commencement of heavy rains which continued intermittently for a week, that sporulation became very active.

Percival (37) found a very pronounced seasonal periodicity in the cast from sporophores at Jamesville, N.Y. In the course of a year, the rate of sporulation reached strikingly high peaks during the first half of May and the last half of November. Throughout December, January, February and March, if occurring at all, sporulation was very light. It ceased completely, however, only during seven weeks of the winter.

During the summer its average intensity measured only about one fifteenth of that attained at the maxima in spring and late fall.

These observations with respect to sporulation, bear out in part Möller's (30) conclusion that the casting of spores might occur at any time of the year, but that it was most active in fall and winter, and comparatively scanty during the summer. By removing the sporophores from the trees, and obtaining the cast in the laboratory Möller proved the potentiality of the fungus to sporulate in the winter. In climates where the winter temperatures are almost constantly below freezing, one could hardly expect much sporulation to occur in winter; but that it does occur at surprisingly low temperatures is shown by trap records in the field and by the following experiments of the writer with sporophores held in cold chambers in the laboratory.

On April 22nd a large bracket fructification, which was sporulating naturally, was taken from a pine at Petersham and brought to the laboratory. On the 24th, by which time it had dried somewhat, and had ceased to cast, it was placed in cold water for an hour and then set up in an ice box at 0° C. After 42 hours it was placed at a temperature of 4° C, and six hours later at 8° C. After remaining in this box for 42 hours, sporulation was quite active, the fructification was removed again to the 4° chamber where it continued to cast for 19 hours. It was then placed at 0° C, and after four hours its activity had almost ceased. Placed again in the 4° C box, it continued to cast spores very lightly for 44 hours, and then stopped definitely. No further activity could be induced at any temperature.

A similar sporophore collected at the same time as the first, instead of being refrigerated, was placed under a bell jar above a water surface at the temperature of the laboratory. After 40 hours sporulation was active and it continued so for 12 hours, when it became perceptibly less. During the next 50 hours it was very light and then ceased definitely. Another fructification was allowed to dry in the laboratory until June 15th, when it was soaked in cold water for two hours, and then placed under a bell jar. After only six hours sporulation commenced and continued rather lightly for 18 hours. The discharge was then somewhat heavier for a period of 12 hours when it began to diminish, continuing, however, at a reduced rate for approximately 24 hours.

The first specimen, two days after collection, after soaking, required an induction period of 90 hours at temperatures of 0° C to 8° C before sporulation commenced. Having started, sporulation continued for 72 hours at temperatures never above 8° C. The second specimen, kept throughout at the laboratory temperature of 70° to 80° F, was induced to

sporulate 40 hours after soaking, and continued for 62 hours. The third specimen, air-dried for three weeks, began to sporulate at laboratory temperature six hours after soaking, and continued for 54 hours.

It seems not improbable that the cessation of spore casting by detached sporophores is due to the exhaustion of protoplasm available for spores. Similarly, one is inclined to believe that in cold climates, while a winter thaw may induce a single period of sporulation, such is at the expense of the sporophore itself, which soon becomes exhausted; and further activity is prevented on account of the mycelium in the tree being quite inactive. The slow thawing of the trunks of large trees might also explain the apparent tardiness of sporulation in the spring.

11. Sporophore Production in Culture

No success has attended the writer's attempts to induce the development of sporophores on agar *in vitro*. Two dozen cultures of different origin on potato-dextrose agar and malt-agar in 1¼ inch tubes, were held in the laboratory for a period of 18 months, by which time they had become quite dry. No fructifications had formed, although there was a heaping up of mycelium into cushion-like masses in many of the tubes. Nor did any sporophores develop during the course of over two years on small bolts of pine showing red rot and some white pocket rot, which had been taken from living trees, brought to the greenhouse, and set up in shallow pans of water. Percival (37), however, reports the development of "rudimentary sporophores" in flask cultures on small blocks of *Picea rubra, Abies balsamea,* and *Larix laricina.* Fritz and Rochester (8) have noted the formation of sporophores on jack pine blocks in flasks, eight months after inoculation.

12. Inoculation and Infection Courts

The fungus is dispersed by means of basidiospores which are wind-borne to the infection courts. Weir (45), having observed that ants and bees frequently inhabit the rotted trunks, and that bees often rest on the surface of sporophores, has suggested the possibility of insect carriers. To account for rot of the cavity type, confined to butts and large roots, soil-borne infection or infection through contact of diseased with healthy roots has often been proposed. As a matter of fact, only one instance of the latter has been proved, a case in which the mycelium of the fungus passed from one deodar to another through a natural graft of the roots (17). In white pine such instances must be rare, if indeed they occur at all; for in

this species the fungus is never found in small roots far from the stump, and grafts between individuals are not at all common. Möller (30) and Hole (16) have proved the preponderance of wind-borne infection for the regions in which they worked, and there appears to be no reason for thinking it otherwise elsewhere. They were not concerned particularly with cavity rot, however, and it has always been infections of this type which have been difficult to recognize as of wind-borne origin. Such infections have in the past been the subject of disagreement and misunderstanding. Actually, there is a very simple explanation of the cause of cavity rot, which admits wind as the disseminating agent of the pathogen, and the branch stub as the usual court.

Argument has centred around the question of the infection court. Runnebaum (30) voiced an opinion, apparently rather widely held among German foresters in opposition to Möller's insistence on branch stub infection, that infection took place through the roots. According to his experience, most of the fructifications of the fungus on the trunks of Scots pine occurred close to the ground, and the rot was often confined to the lower trunk and roots. Moreover, such rot was frequently found in trees, the stubs of which, on the basal part, had long since been completely overgrown. Runnebaum did not deny the occurrence of branch stub infection, but held that infection through the roots might be very common. In support of his contention, he described a stand in which he claimed that of seventy diseased trees, fifty had been infected through the roots.

In America Hedgcock (15) observed *Trametes Pini* rot in roots and said that it was apparently communicated from tree to tree underground through contact of diseased with healthy roots. Sher Singh (43) expresses the opinion that in deodar forests, where the disease is said to be common in the butts, infection takes place underground. The present writer agrees that *Trametes Pini* rot is common in the butts of trees. Under certain circumstances it is a prevalent condition among young trees, and in old trees it assumes a distinctive character as "cavity rot." The infection courts are not in the roots, however, but at the basal branch stubs of young trees.

Infection originating at large branch stubs in the mid-trunk section of older trees, has long been recognized, and that it is of common occurrence cannot be doubted. In mature western white pine Weir and Hubert (50) found slightly over seventy-five per cent of infections originating at such courts. Boyce (2) says that in the Pacific northwest, practically all infections are through branch stubs or knots. Again (4) he records that in certain stands of mature Douglas fir, eighty-three per cent of *Trametes Pini* infections were through the branch stubs. The present writer has

found that in mature white pine there is, with increasing age, greater mechanical damage in the crown, and that crown infections are commoner in very old trees than in those younger. On the other hand, in such timber recent trunk infections are practically unknown, on account of the almost complete protection afforded by covering of the stubs, and the heavy bark.

Our knowledge of the trunk rots has heretofore been derived largely from the examination of mature trees felled in the course of logging operations. Little attention has been given to branch stub infection in young trees, and particularly in the butts of young trees, where they first become susceptible. As far as branch stub infection is concerned, we should envisage a zone of susceptibility beginning in young trees at the ground level, increasing in width, and passing slowly upwards as the growth of the trunk covers the stubs.

The young pines studied by the writer were mostly between fifty and sixty years of age, and had boles clear of living branches to a height of thirteen feet or more. Among the diseased trees the shortest clear trunk was 13.5 feet and the longest 30.0 feet, measurement being taken to the lowest green branch. Nearly all these trees still retained some dead branches almost to the ground. The branches at the very stump, formed as laterals of trees only a few years old, were in most cases completely covered, after having been broken off; but occasionally only three or four inches above ground, very small branches one-tenth to one-half inch in diameter still projected from the trunk. The butts of these trees were rapidly reaching a condition, however, when owing to coverage of all stubs they would be completely protected against such infection there.

Of the thirty diseased individuals among the 189 living white pines examined on infected plots, there were thirty-nine separate infections, possibly a few more. Fifty-seven per cent of all infections had with certainty taken place through branch stubs. Adding those cases in which it is very probable that infection took place in that way, the percentage is seventy-seven. The concentration of infections in butts was most marked; over a third of them originated within two feet of the ground, and two-thirds of them below breast height. The remainder were scattered at various points higher up on the trunks, two occurring above the lowest green bough, through the stubs of very small dead twigs.

While the precise conditions that control branch stub infection are still unknown, some interesting data bearing on this subject are to hand. As already pointed out, many infections had taken place below two feet, through very small branches. Branch stub infections (K. in Table No. 3) were identified by the presence of a "punk knot" connected with the main

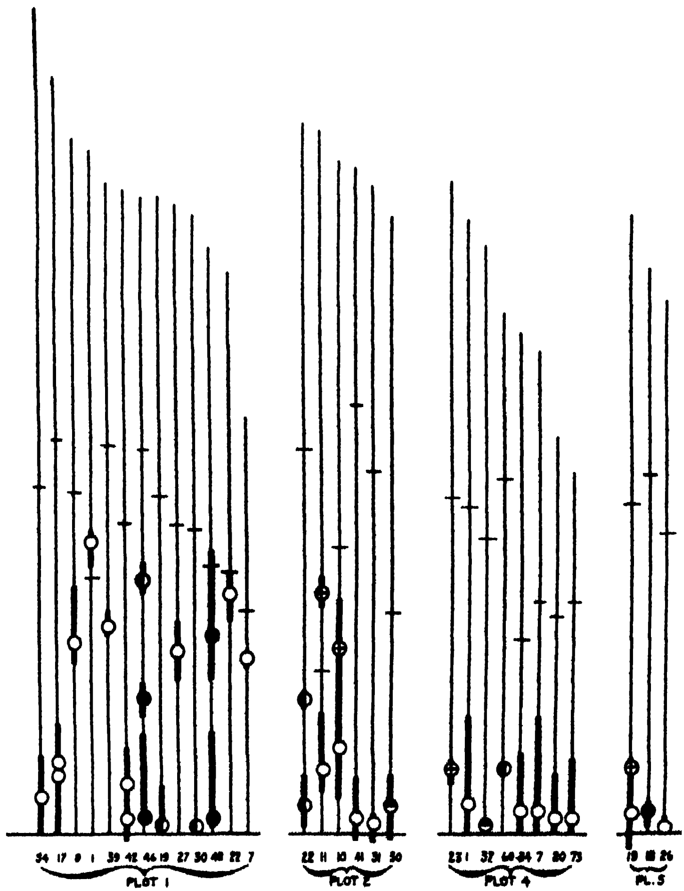

Fig. 1. Character and locus of infection courts, and position of rot in trunks. Scale: 1 inch = 14 feet. Plot trees.

LEGEND

- ○ Branch stub (with "punk knot")
- ◐ Branch stub (with no "punk knot")
- ● Wound
- ⊕ Weeviled top
- ⊖ Unknown (probably branch stub)
- — Position of lowest green branch
- ▮ Position of rot in trunk

body of decay in the tree, to which there was no other avenue approaching from the outside. It is unusual to find in forest grown pines branches of more than one-half inch diameter less than two feet from the ground. While under the conditions of natural reproduction, individuals will vary considerably in regard to trunk clearing in the seedling and sapling stages, it is common to find seedlings eight or ten inches high, in which the lowermost laterals an inch or more in length, are already dead or dying, presumably through natural physiological causes. By the time the tree is eight or ten feet high, these lowermost branchlets may already be covered with wood; but about a foot or less from the ground there are to be found numbers of laterals, perhaps four to eight inches long, and about one-tenth inch in diameter. Many of these, after death, if not actually pinched off by the constricting pressure of the surrounding growing region, are compressed, and become so brittle that the slightest accident will remove them. In nature, many of these small branches are broken off a few years after dying. Doubtless the accumulation of snow and ice on them in winter is a not unimportant influence. Higher up the trunk the dead laterals are naturally larger, so that in forest grown pines at breast height, they are commonly from a quarter to half an inch in diameter, and of course much larger if the trees have grown in the open. It is very common, however, to find at the whorls among these larger branches, a few small twigs no more than one-tenth inch in diameter. Among dominant trees in any close-grown forest stand of pines, there will be few branches below breast height which have lived more than eight or ten years. Indeed five or six years seem to be more common ages. It is through these and smaller branch stubs that infection of the butts takes place. Many trees were found which had been infected through stubs one-quarter inch or less in diameter, which had no more than five annual rings. In all such cases found, infection had taken place through a broken stub, or at any rate through one which at the time of examination was so short that it did not project beyond the surface of the trunk. A few infections had taken place through extremely small stubs, in which cases it was impossible to determine whether breakage had occurred or not. Tree No. 26, Plot 5, a codominant 53 years of age, had been infected through a stub only one-twentieth inch in diameter, four inches above the ground.

A few infections were found in which it seemed altogether probable that branch stubs had been the means whereby the fungus had entered, but on account of the absence of a "punk knot" or other definite indication, they were not identified positively as branch stub infections. These are indicated in Table No. 3 as (K). For instance, in the case of tree No. 19, Plot 1, an intermediate 49 years old, an infection was centred around a

branch stub 0.5 feet from the ground, with no other apparent avenue of ingress. The stub, which was about one-eighth inch in diameter showed a reddish stain characteristic of *Trametes Pini* decay in its early stage, and there was a slight flow of resin from the base of the stub down the trunk.

Again, in a few cases it was impossible to identify the infection court at all. Such are indicated in Table No. 3 by (?), and include infections in tree 30 in Plot No. 2, and 37 in Plot No. 4. In these cases there were no "punk knots", or any apparent decay in the knots in closest proximity to the centre of infection. Yet it seemed probable, from the position and character of the rot in the trunks that infection had taken place through the stubs whose position is indicated in the table. Although fairly extensive, particularly in the case of tree No. 30, Plot No. 2, where it ended blindly in a root 0.5 feet below the ground, the rot in each case was not advanced beyond the red stain stage, even where apparently of longest duration. As careful search failed to reveal any other possible courts, it may be suspected that infection had taken place through the stubs, but that there had not yet been time for the development of "punk knots."

The assumption that, in the case of the true trunk-rotting fungi infection takes place largely through the branch stubs, has been current since Hartig's day. There is little reason to doubt its correctness in so far as *Trametes Pini* is concerned, but it is a fact that the process has not been demonstrated. It is important to note that little is known as yet of the nature of these courts and the manner in which infection takes place through them. Hartig (12) believed that branches which die naturally on the tree do not provide good infection courts even if broken. He believed that the infiltration of resin at the bases of such branches, the drying of the wood, and the presence of saprophytic fungi, more or less effectively prevented the growth of *Trametes Pini* there. Again (14) he suggests that the surface covering of resin is the important protecting agency, and that trees with only small branches, in which heart wood has not formed, are immune on account of the fact that their broken ends are quickly covered with gum. Möller (30) adopts this view and states emphatically that trees are absolutely safe until heart wood is formed in the branches. He is opposed by Runnebaum (39) and others who point out that in dense pole stands the lower branches of the trees are short lived and could not have formed heart wood; yet such small trees are often infected.

The present writer has little experimental evidence to contribute towards knowledge of this phase of the disease. Seventeen branch stub inoculations were made at Achray in the hope of demonstrating infection through such courts. Owing, perhaps, to the shortness of the experimental period

(fourteen months) and the difficulty of examination of the specimens, the results were inconclusive. In one instance the fungus was cultured from a point in the stub approximately 1 cm. from where the spores, dispersed in water, had been deposited. The data collected with reference to this experimental trees are as follows: Age (when cut)—40 years. D. B. H. —4.5", Ht.—25'. Age of trunk at court—34 years. Diameter of stub inoculated—38/50". The method of inoculation was as follows: The branch, which had been dead three or four years, and still retained a tight bark, was cut off with a fine saw one inch from the trunk. A 1/8" auger hole was bored in the stub to a depth of approximately half an inch. A few drops of a suspension of fresh spores in sterile water were then introduced by means of a dropper, and the hole plugged with cotton. The stub was then capped with hard grafting wax.

Superficial wounds may provide suitable infection courts, providing there is a substratum of dead wood. The occurrence of sporophores springing from dead sapwood, the growth in culture of the fungus on such wood, and the discovery of infection through exceedingly small branch stubs, prove that dead sapwood provides a satisfactory substratum for growth. In nature, wounds not infrequently become infection courts. Special note has been made by various observers of infection through wounds caused by fire, logging equipment, falling trees, barking by deer and squirrels, the blazing of trunks and the breaking-off of branches. That fire scars are relatively unimportant appears to be established (2) (3). The reasons for this are still rather obscure and will remain so until the precise conditions controlling infection are known; but the fact that fire scars are usually at or near the ground doubtless accounts for the prevalence of root and butt rots in fire-damaged timber, a condition which inhibits the growth of *Trametes Pini*.

On the 189 young pines examined by the writer on plots in which *Trametes Pini* was present, there were nine wound-courts, distributed on seven trees. Four were inflicted on two trees by a falling trunk—a fire-killed veteran of the parent stand. One other tree had been injured by having its top broken off by an unknown agency when about seven years old. This tree developed a "punk knot" at the infection court at a very early age. Four trees had become infected at weeviled tops a type of wounding common enough in white pine, but not heretofore recognized as a possible infection court for *Trametes Pini*. These cases are of particular interest in indicating clearly that trees may be infected through killed wood only a few years old. That such wood provides quite favourable opportunity for the development of the disease is apparent from the prevalence of infection through exceedingly small stubs.

13. THE INFECTION OF WHITE PINE IN RELATION TO AGE

Trametes Pini rot, as well as the other common trunk rots, is usually regarded as a disease of mature and over mature timber. This opinion is based on the common observation that in old timber, the volume of rot is, as a rule, larger than in younger stands. The long-continued growth of the fungus in the tree naturally results in a cumulative volume of rot, and in old timber the current decay may well more than offset the current increment. Moreover, the longer the exposure of a susceptible individual to the chance of infection, the greater the number of infections of that individual there will be. Therefore, in a stand, providing the chance of infection remains, there will be with increasing age an increasing number of individuals infected.

While there is obviously an element of truth in designating *Trametes Pini* rot as a disease of old timber, if it is true that infection of the host can and does take place at an early age, such designation is erroneous and misleading. On the question as to the age at which trees become susceptible, there is a certain amount of observational and experimental evidence which may be briefly reviewed. Hartig, with reference to Scots pine, constantly contends that in living trees the fungus will grow only in the heart wood and that until heart wood is formed the trees are immune. His several attempts to infect 30 to 40 year old Scots pine by placing a cylinder of decayed wood in a boring in the trunk of a healthy tree, never succeeded. With older trees, on the other hand, success was the rule. He considers that susceptibility in the Scots pine usually develops between the fortieth and fiftieth years, although he admits discovery of infection in a tree as young as 30 years (12).

Later, from those who opposed Hartig's insistence on branch stub infection, and proposed infection through the roots to account for a type of *Trametes Pini* rot commonly found in the butts of trees, there came evidence of infection taking place at a still earlier age. A stand of Scots pine scarcely more than 20 years old contained a considerable number of trees with *Trametes Pini* butt rot. One tree 23 years of age bore a fruit body of the fungus (31). Hole (16) says that in Simla, *Pinus excelsa* of all ages is attacked, and he ascribes the common occurrence of the rot in older trees to their longer period of exposure rather than to a greater resistance in the younger trees. He found fructifications most abundant on trees which he estimated to be from 20 to 40 years of age, but had little opportunity of seeing a proportionate representation of older trees. He quotes Mayes (23) on the subject to the effect that the fungus is found on trees of all ages but most commonly on the mature individuals. In America there are few references to the occurrence of *Trametes Pini* rot in

young stands. Weir and Hubert (50) found from work in mature stands in the western states, that few western white pines below the age of 80 years were infected by any trunk- or butt-rotting fungi. They consider that the "age of infection" may be taken as beginning about the fiftieth year. "Age of infection" as interpreted by these authors, however, means the age at which rot becomes conspicuous. Meinecke (25) gives the infection age in this sense for heart rots in white fir at about 60 years.

With regard to precise information as to the earliest age at which infection by *Trametes Pini* can take place, Neuman (33) records finding a white pine only 25 years old bearing a small sporophore one foot above ground. On examination, the heart of the trunk was found to have been decayed from a few inches below ground to a point nearly four feet above. The tree had been wounded near where the sporophore was growing, when only 7 years old. Although infection may not have taken place for some years afterwards, it seems reasonable from the extent of the rot in the trunk and the fact that a sporophore had been produced, to deduce that the tree was not more than 20 years old when infected. Boyce (4) records the discovery of a Douglas fir only 4" D.B.H. and 24 years old at one foot from the ground, with heart wood decayed throughout, and bearing four small sporophores of *Trametes Pini.*

The writer's studies in young white pine throw a certain amount of light on the question of the age at which this species may become infected. The plots on which these studies were made are decribed elsewhere in this paper. There can be little doubt that the trees on them were exposed from the seedling age onwards to a rather high chance of infection, which however, diminished sharply after twenty-five years or so, since which time the chance has been low. A surprisingly large number of these trees, which ranged in age from 39 to 64 years, and averaged about 54, were infected. It is very difficult to arrive at the precise age at which infection took place in any individual. However, a number of trees exhibited conditions which allow of an approximation being made. In Plot No. 1, trees 46 and 48 were both wounded twenty-five years ago by the fall of a very large white pine chicot, left from an earlier stand. At that time tree No. 46 was 29 years old. A stub from the falling chicot opened two wounds on the young pine, one extending two feet upwards on the trunk from a point two feet above ground, and the other extending from 8.5 feet to 9.5 feet. Twenty-five years ago, at nine feet from the ground the stem was 17 years old. The wounds when found were still open, and infection may have taken place at any time subsequent to the fall of the chicot. But the fact that a small fructification had been produced at the upper wound, and that the rot in that locality was in the white pocket

stage, would lead one to think that it had not been very recent. If we assume that it occurred only five years ago, after twenty years' exposure, at the court at nine feet the tree stem would be only 37 years old. The probability is that infection took place much earlier.

A study of tree No. 34, Plot No. 4, yields interesting information. This tree was scarred on the butt by fire forty-four years ago, when 9 years of age. The wound was utimately completely overgrown. Subsequent to wounding, the tree became infected through a branch stub on the opposite side of the trunk, as was clearly indicated by the ring type of rot developing from the knot. Twenty-five years ago, the infection caused the characteristic bull grain symptoms to appear in the callus growth which had then partially covered the face of the old fire scar. Thus the fungus had worked to the surface of the fire scar on the opposite side. It is quite safe, therefore, to assume that infection took place at least twenty-five years ago, at which time the tree would be 28 years of age. Tree No. 23, Plot No. 4, had its leader weeviled 4.5 feet from the ground when approximately 8 years of age. Some time subsequently, infection developed in the killed part. The dead stub of the leader became completely buried in the trunk twenty-five years ago, when the tree was 21 years old. It is thus apparent that the tree became infected some time between the age of eight and twenty-one years. Similarly, in Plot No. 2, tree No. 10 was weeviled thirty-six years ago, when 17 years of age. The dead stump of the leader, ¼ inch in diameter, protruded from the trunk until two years ago, by which time it had been completely covered. Infection may have taken place any time after seventeen years. Tree No. 11, Plot No. 2, had its leader weeviled thirty-seven years ago, when 18 years old, and became infected at that point some time subsequently. At the time of examination, when the tree was 55 years old, the dead stub of the leader still protruded from the trunk. Tree No. 26, Plot No. 5, a co-dominant 53 years old, had been infected four inches above ground through a stub only 1/20″ in diameter. This stub was completely buried at the time of examination. The punk knot, however, extended to the surface, a distance of approximately 2½ inches. This represented twenty-five years' growth. Therefore, if the symptom of punk knot developed immediately after the infection, we could say with confidence that the tree had been infected about twenty-five years ago, when 28 years of age. It is certain that it occurred no later, for the punk knot structure is produced only at the cambial region. In all probability, it took place somewhat earlier, for it is reasonable to suppose that a period of a few years would elapse before the fungus would be well enough established to induce the beginnings of a punk knot.

An instance of infection at a still earlier age was recently discovered

by the writer and has been fully described elsewhere (11). The tree involved had suffered the breakage of its stem when 11 years old, at a point one foot above the ground. At this point the stem was then 5 years old. The wound became infected and a punk knot developed. Its position with respect to the growth rings showed clearly that it had originated not later than when the tree was 16 to 19 years old. Infection must have taken place somewhat earlier.

Thus it is clear that white pine may become infected when less than 20 years old, and that injuries inflicted on very young trees may provide infection courts before they are healed. Therefore, under favourable conditions for disease, which implies a high concentration of inoculum and a large number of infection courts, white pine stands may become infected during their period of establishment.

14. The Infection of White Pine in Relation to Tree Class

It is a curious fact that on the plots studied by the writer the incidence of infection among dominant and co-dominant trees is higher than among members of the other classes. Of the 189 trees of all classes examined, 16 per cent were diseased by *Trametes Pini*. Among the 88 dominants and co-dominants 25 per cent had become infected. But among the 38 intermediate only 12 per cent were infected, and of the 56 suppressed trees, there were only 5 per cent infected. This summary is approximately representative of the situation on each plot. (See Table No. 2).

The explanation of the relatively high rate of infection among older and larger trees as compared with younger and smaller is to be found in the forest history, which is that of a young stand following an old and defective one destroyed by fire. What has been learned of the fruiting habits of the fungus indicates that a grand fruiting period succeeded the fire, and coincided with the establishment of the new stand. It is apparent that the oldest and largest trees during that time, as represented in the main by the present dominants and co-dominants, would be those first to attain susceptibility. At that young age, infections must necessarily have been at a point not far above ground. The actual concentration of butt infections found in the trees at the time of examination, confirms this interpretation and supports the explanation given of the high rate of infection among dominant trees.

15. Forest Protection and Disease Control

The management of any forest property is conditioned by the policy of the owner, and by the actual state of the property. Protection, as a function of management, thus relates to specific instances, and for technical and

economic reasons is inevitably bound in an intimate way with the general management plans. This may be said with particular emphasis of the protection of forests against disease.

Under a policy of sustained yield management, there is entailed a definite control of forest operations, involving the composition and formation of the stands, and the representation quantitatively and spatially of age classes in the forest. Such control, when exercised continuously, results in the development of a general condition which may be said to be characteristic or definitive of this class of forests. "Virgin" forests, on the other hand, do not possess this character; nor such forests as are operated irregularly—forests in which sustained yield is not the guiding principle of management. For them, therefore, protection is essentially a different problem. While it is universally true that the function of forest protection is the prevention of forest damage, yet its success, with respect to the managed forest, is to be measured in relation to the principle of sustained yield; but for other forests it is usually on a basis of liquidation of the enterprise.

But it is obvious that the means of control to be employed are conditioned by the nature of the particular disease concerned, and thus protection may be determinative to a degree of the form of management. By way of illustration of the profound effect which the occurrence of disease may have on forest management, one may refer to the case of chestnut blight in America. In that instance there remained no immediate hope of retaining the host as a component forest species. Direct control was therefore out of the question,—a conclusion reached after fruitless attempts. The one course open then, was to exploit as far as possible the susceptible stock and initiate silvicultural treatment leading to replacement of the chestnuts with resistant species of economic worth. Such treatment results in time, so far as chestnut blight is concerned, in the re-establishment of a sanitary condition of the forest.

The protection policy to be adopted in the case of heart rots, on the other hand, would appear to be different. Enphytotic and characteristically non-lethal, these diseases offer no immediate threat to the maintenance of their hosts as component forest species. To deal with them as with chestnut blight would result in aggravated unsanitary conditions, and increased losses. Indeed, if unchecked, they may threaten the success of a forestry enterprise. That opinion is forcefully voiced by Röhrig (38) when, in reference to a particular instance in eastern Germany, he questions whether large pine timber can be grown there economically as long as the heart rot disease remains uncontrolled.

Among diseases of this class, that caused by *Trametes Pini* is of outstanding importance. Various control measures have been proposed with respect to it. They are based on the principles of an immune or resistant crop, protection against infection, and of eradication of the fungus. In practice they involve one or more of the following procedures: (1) substitution of resistant for susceptible species; (2) preservation of the natural resistance at a maximum through the development of well formed trees and the prevention of injury; (3) development of mixed stands of pine and hardwoods; (4) adjustment of the regulation of the forest to provide for a short rotation for the susceptible species, or for freedom of selection for fellings in the cutting series; (5) special silvicultural treatment, such as sanitation fellings and thinnings, disposal of waste, and direct eradication of the fungus fructifications. It is to the point to examine these propositions critically.

(1) There are some obvious objections to the replacement of susceptible with resistant species. The wide host range of the fungus among coniferous trees indicates at once that this course cannot be of general applicability. It is apparent, too, that suitably adapted species, immune or highly resistant, might not be available for the particular localities (sites) concerned. Yet, since there is a wide difference in the relative susceptibility of various conifers, wherever conversion of the stands towards a higher representation of the less susceptible species can be contemplated, such course might perhaps be justified. As a case in point, both Mayes (23) and Hole (16), have recommended in specific instances the replacement of blue pine (*Pinus excelsa*) by deodar (*Cedrus Deodara*). Coming nearer home we note that throughout a large part of the range of *Pinus Strobus*, its common associate, *P. resinosa* is relatively much more resistant to *Trametes Pini*, and might therefore be encouraged to advantage.

(2) The prevention of injury to trees has long been recognized as of importance in minimizing the incidence of the disease. Hartig and Möller emphasized particularly the danger of permitting the cutting or breaking of branches. Somewhat similar injuries may be caused by meteorological agencies, and by operations incident to logging. These, and the injuries due to fire and pests (for example—the white pine weevil) may become infection courts for *Trametes Pini*, and are to be guarded against. This naturally brings up the question of danger of infection following pruning operations.

Hartig believed that infections were common only through freshly broken branches in which heart wood had formed. He considered that there was an effective protection in branches which had died naturally, through the presence of resin in their bases, the dryness of their wood and

the presence of saprophytic fungi. He believed that small green branches effectively covered their broken surfaces with resin, and thus resisted infection. In pruning pine, therefore, he advised against the cutting of large green branches which had formed heart wood. The present writer has found that in white pine, branches only a very few years old and less than one-tenth inch in diameter may provide favourable infection courts, as do also the killed leaders of the current season's growth. Actually, the precise conditions under which infection takes place and its course are still unknown. It is thus impossible to state whether, or under what circumstances, pruning wounds may become infected. It may be said, however, that in localities where the fungus is abundant, infections will occur whether the trees are pruned or not; whereas if the fungus is rare or absent there will be few if any infections in pruned or unpruned stands.

(3) That mixed woods usually suffer less from *Trametes Pini* disease than do stands of pure conifers is a belief shared by many foresters and woodsmen in America and Europe. Thus arise recommendations of mixed forest culture (38). To what conditions exactly the alleged superiority is due is not apparent, but there can be little doubt of its existence. What has been said with regard to protection against risk of infection applies here, for the normal development of pine in mixed stands is often superior to that which occurs in pure stands. The screening effect of broad-leaved trees may, too, be of some significance.

(4) Proposals for the control of heart-rot diseases through the adjustment of regulation to provide for a short rotation have been offered both in Europe and America. On this continent, largely on the basis of studies made in virgin stands in western forests so-called "pathological rotations" have been suggested for several species.

A number of questions arise with respect to this term and the concept which it embodies. Is the "pathological rotation" to be regarded as a genuine rotation, serving some definite goal of management? It might then be classified conventionally as a physical or silvicultural rotation, the stand "maturing" on account of having reached the limit of soundness. That such "rotations" exist in nature and that they may have some significance to forestry, can scarcely be doubted; yet one hesitates to regard the attainment of an arbitrary degree of faultiness or even the ultimate elimination of a species through decay as constituting a condition of stand maturity. Nevertheless, if the "pathological rotation" is to be regarded as a rotation at all, it must be accepted as a physical or silvicultural rotation. It is well known that such rotations are not related theoretically to rotation for maximum yield or revenue. That this fact was appreciated by Meinecke (25) who coined the term, is clear, for he used it with hesitancy—"for

want of a better expression"—and intimated that the "pathological rotation" indicated a limitation to feasible rotation length for the species concerned. The question as to the validity of the general application of data derived from age-rot studies remains to be considered.

That a correlation exists between age and incidence of decay, as postulated in the theory of the "pathological rotation" can scarcely be doubted. It has been shown for several species by Meinecke (25), (29), Boyce (4), McCallum (24), and others for certain fields of reference. For practical forestry purposes, however, we are interested in particular instances, and before accepting a "pathological cutting age" as of specific application it is necessary to consider the character of the instance involved. There are factors other than age which are determinative of the amount of decay in a tree or stand, and in some instances such factors may be of paramount importance. This consideration has been appreciated by the authors referred to. Thus Meinecke (25) recommends the delineation of zones of relative importance of cull factors. Boyce (4) and McCallum (24) are careful to point out that from their data, derived from virgin forests, one cannot predict the pathological felling age in forests where any cultural treatment is given, or where forest conditions are different from those in which their studies were made. Yet there is, perhaps, a tendency towards a facile acceptance of the short rotation as the solution to the problem of control of heart-rot diseases, and for this reason, and on account of the danger of exaggerating the field of reference of pathological felling ages already determined, further discussion of the subject is called for.

In extensive tracts of virgin forest, particularly in forests which have developed to a relatively stable condition floristically, it may be assumed that forest conditions are generally more uniform over large areas and over long periods of time than elsewhere. With respect to *Trametes Pini* disease, one may assume that then the variation of the chance of infection in different localities and at different times is at a minimum. Thus it is to be expected that in forests of this character there will be a high degree of correlation between age of stand and amount of rot. But even in the virgin forest there is actually a wide range of forest conditions from place to place and from time to time, the same species occurring in associations or types of very different character, according to their range of adaptability, or the occurrence of catastrophic changes. Thus it is to be expected that the abundance of the fungus in the forest will vary in time and place and that the chance of infection in different stands may vary considerably, and that stands of the same age may not have the same amount of rot. The data presented by Meinecke (29), Boyce (4), McCallum (24) and others show this clearly enough, just as they show that old stands usually have

more rot than young ones. Boyce (4) says with respect to Douglas fir in Washington and Oregon: "There is no explanation why certain stands may attain old age with little rot." Weir (46) says: "Jack pine reaches its normal ages on the dry pine barrens of the lake states without much defect of the wood from fungus diseases, although exceptionally old trees of ninety years or more frequently show considerable decay. In mixture with other species, in the moist regions of its range, particularly in parts of northern Minnesota and Canada, *Trametes Pini* causes considerable heart-rot in trees sixty years and older."

Under conditions of civilization the differences in the forest condition of stands of the same species are apt to be intensified, and one would expect corresponding differences in the incidence of decay. Thus Abbott (1) says of *Trametes Pini* disease in white pine in New England: "Previous writers have ascribed much importance to the supposed fact that only the oldest trees in the stand are affected. Many specimens of trees not more than twenty-five to thirty years old were found by the writer to be infected. . . . Many small tracts, especially isolated ones, were found where no disease was apparent. . . . The distribution of the disease is irregular. Along the shore of Lake Champlain tracts less than ten miles apart were located where both extremes of condition were found. The Connecticut valley shows a similar condition."

As a result of information gained from foresters regarding the prevalence of *Trametes Pini* rot in pine stands of various ages in the forests under their charge, Möller (30) concludes that it is obvious that little can be said with precision in regard to the age rot ratio in particular instances, but that it is also obvious that in general, with increasing age, there is a higher incidence of decay.

The present writer has noted cases of extreme variation in the amount of rot on account of *Trametes Pini* in second growth white pine stands of approximately the same age. In Norfolk county, Ontario, many stands cut at sixty to ninety years of age, are practically free of rot. Occasionally it is present to an extent which seriously prejudices the success of the lumberman. In one case recently observed, approximately fifty per cent of the lumber sawn from a ninety-year-old stand was more or less seriously stained or rotted.

The present criticism is offered only against unwarranted assumptions with respect to the constancy of age-rot ratios. It is based in part on evidence available in the data already accumulated, and in part on theoretical considerations of the character of the wood rot diseases. It is clear that the abundance of the fungus in fruit in the forest is a primary factor influencing the rate of infection. That this may vary greatly in time and

place has been established. Woods operations, moreover, can modify the degree of exposure and herein lies an opportunity for valuable means of control. As Martin (22) points out, the entrance of *Trametes Pini* into stands is to be regarded by the forester as an abnormality. He admits that the prevalence of the disease varies greatly in different localities, and that often it is not uniformly distributed even in the same compartment. He emphasizes the importance of "stand maintenance" through sanitation thinnings.

One may point out that it may be impossible to reconcile a short rotation with the objects of management. A case in point which has recently been brought to attention by Röhrig (38) is that of pine in the Potsdam district of the Prussian State Forests. In this instance the production of high quality timber is threatened through the ravages of *Trametes Pini*, but the rotation cannot be lowered for technical reasons, namely the necessity for growing large timber of high quality.

(5) Silvicultural control of *Trametes Pini* involves the gradual elimination of the fungus from the forest through free selection for cutting, irrespective of age, according to the pathological condition of the trees or stands. These cuttings are essentially sanitation cuttings, made with the double purpose of salvaging the timber and ridding the forest of the fungus. They are, therefore, fundamentally silvicultural in character, and it is apparent that under the selection system they would be indistinguishable from sanitation thinnings. This policy was generally applied in even-aged pine in state and crown forests in Germany, particularly at the beginning of the *Trametes Pini* eradication programme sponsored by Möller. It became quite generally modified to a thinning practice for several reasons—a disinclination to sacrifice the quality growth of sound trees, the discovery that the disease was not evenly distributed or related to compartment boundaries, and that it was often present in quite young stands and, finally, on account of the over supply of the market with timber, to which the heavy clear cuttings led. Actually, the practice was often favoured for silvicultural reasons.

In the course of the development of Möller's programme, it became more and more apparent that satisfactory control of the disease was to be achieved only through "banishing the fungus from the forest." This attitude resulted from an appreciation of the fact that infection could take place at an early age. Thus the emphasis was laid on the establishment and maintenance of sanitary conditions in the forest through the eradication of the fungus. This was achieved through sanitation thinnings in the young stands, thinnings or clear cuttings in the old stands, and the removal of sporophores from the trees when for any reason they could not be cut.

The removal of sporophores was an expedient measure, intended to save the younger trees from further infection, and was necessary largely on account of the inability of the market to absorb within a short period the infected timber which, on technical grounds alone, would have been cut.

This policy is of general reference, applicable under any system of silviculture, and is theoretically sound. There are technical difficulties in its application, chief among which is the identification of infected trees. The danger inherent here is partly obviated through the practice of removing sporophores. Actually, on account of the difficulty of detecting infected trees and of removing sporophores, a sacrifice of older timber may be entailed during the period of establishing sanitary conditions in the forest; but it is believed that in the younger stands, most infected trees can be removed in thinnings before sporophores are produced in any abundance.

Möller's campaign in pine forests of eastern Germany for the control of *Trametes Pini* is the most important instance of such effort of which we have knowledge. However, according to Röhrig (38) it cannot be considered to have been completely successful. This he ascribes in the main to the failure to pursue energetically for a sufficiently long time the programme of eradication, a failure incident to the outbreak of the war. But Röhrig also considers that the clear cutting system generally in vogue for pine does not lend itself readily to the achievement of control, in that thinnings are normally too infrequent and that there is an undesirable concentration of old (and possibly defective) timber. He welcomes the introduction of a more intensive thinning practice.

As pointed out in the beginning of this section, every forest property presents a problem with respect to protection against disease which is to a greater or less extent peculiar to itself. The protection policy must be determined in the light of the actual condition of the forest concerned, and in view of the general plans under which it is managed. The original work recorded in this paper was done for the most part in virgin forest, and can have no direct reference other than to the particular instances involved. Nevertheless it is believed that from the knowledge of the disease gained thereby, particularly with respect to its epidemiology, certain generalizations may be drawn. One may summarize the salient features of the *Trametes Pini* disease in white pine which have a bearing on forest management as follows: (a) Under the most favourable circumstances white pines may become infected at twenty years of age or less. Natural stands of pole-wood size, as occurring in Ontario, if exposed to a high risk of infection, readily become infected. (b) Susceptibility is first developed in the base of a tree, and passes gradually upward with its growth, the lower part of the trunk becoming normally less liable to infection on account of

the natural protection acquired with age. The extent of susceptibility within an individual is determined largely by the amount of matured heart wood, and thus increases with age. (c) The concentration of inoculum in the forest is a primary factor determining the rate of infection, and is dependent on the abundance of the fungus in fruit. Fruiting is most prolific on dead wood, and grand fruiting periods occur whenever large volumes of infected wood are left on the ground. The duration of such periods depends on the rate of fall of infected timber, the size of the pieces on the ground, their exposure and rate of decay. It may persist for over twenty years. (d) Optimum conditions for fruiting occur only locally, and stands of susceptible species other than pine may be the source of most of the inoculum present in the forest. (e) Living infected pines bear comparatively few fructifications, but show a considerable variations in this respect, according to their age and quality. Trees exposing the largest surface of dead wood bear fructifications most freely.

The technique of control must be modified according to the character of the forest. A selection forest cannot be treated in the same fashion as one composed of even aged stands. Yet it may be asserted that success in control is to be attained in one of two ways, or through a combination of both, namely, by exploitation before excessive damage has accrued, or through the suppression of the fungus in the forest. The short rotation is more or less effective towards both ends, in that cutting at an early age minimizes the amount of decay in the crop, and tends also to prevent the fungus from fruiting abundantly. Forest sanitation, through close utilization, sanitary thinnings and fellings, and the destruction by burning or other appropriate disposal of unavoidably waste material, will improve the health of the forest, and if thoroughly prosecuted will in time eliminate the disease.

16. SUMMARY

This paper deals with *Trametes Pini*, a coniferous wood rotting fungus, and the disease which it causes in white pine forests. Reference is made to the important literature on the subject and to the names given to the fungus and the decay which it causes. The disease is interpreted as being parasitic and enphytotic in character, and of considerable importance to forestry. An indication of its prevalence and destructiveness is offered through a review of the records of damage available. The results of studies at several localities in virgin pine forests in Ontario confirm the belief that it is by far the most destructive heart-rot disease of that species. *Trametes Pini*, while characteristically a heart rotting fungus, is never-

theless definitely parasitic in pine. It causes, typically, decay at the mid-section of the trunk, but is also often the primary cause of a common butt-rot condition in old pine named "cavity rot", the etiology of which, while not thoroughly known, implies early infection by *Trametes Pini* through branch stubs near the ground.

Signs and symptoms of the disease are described. Perhaps the most interesting is the so-called "punk knot," which is a pathological structure developing around or extending from embedded branch stubs, as a result of infection in or near adjacent meristems of the trunk. The detection of infected pines in the woods, a matter of practical importance, is possible largely on the basis of the occurrence of "punk knot" and associated symptoms.

The fruiting habits of the fungus are of significance in the spread of the disease. Fructifications on living white pine in northern Ontario are rare, but they are common on infected dead wood of large dimensions, and in the virgin forest the largest amount of inoculum originates from this source. Cull logs from infected trees, as well as windthrown timber, produce prolific crops of sporophores for many years, and reproduction in time becomes infected from the debris resulting from the destruction of the parent stand.

The fungus sporulates periodically, the greatest activity occurring in spring and fall. Sporulation takes place at surprisingly low temperatures.

A study of the infection courts in trees on plots laid out in virgin second-growth white pine stands revealed the fact that infection through small branch stubs near the base of trees was of frequent occurrence. In this way is initiated the "cavity rot" found in old trees. It is confirmed that most infections occur through branch stubs, but very small branchlets only a few millimetres in diameter and only a few years old may provide favourable courts. The killed leader of the current season's growth may ultimately become infected. Instances of the occurrence of infection following weevil injury were discovered.

Plot studies showed that white pine may become infected at an early age. One tree was found which indubitably had become so when less than twenty years old. Among the various classes of trees, the dominants showed a higher incidence of infection than others.

Forest protection is inevitably bound up in an intimate way with the general management of the forest property. The policy of the owner and the actual state of the forest, as well as the character of the disease, are to a degree determinative of protection policy. *Trametes Pini* disease is of peculiar interest on account of its widespread distribution and endemism and its non-lethal yet destructive character. Various proposals have been

made for its control, as follows: (1) substitution of resistant for susceptible species, (2) preservation of natural resistance at a maximum, (3) development of mixed stands, (4) introduction of a short rotation, (5) sanitation fellings and thinnings, close utilization and disposal of waste. These proposals are reviewed critically, and the so-called "pathological rotation" is discussed.

17. ACKNOWLEDGEMENTS

The writer is indebted to many persons for help in various ways during the time that this study was in hand. Very substantial assistance, for which acknowledgement especially is due, has been received from the following: Professor J. H. Faull, Arnold Arboretum, Harvard University, under whose direction the study was commenced, and whose advice and criticism given throughout, have been most valuable; F. A. MacDougall, Algonquin Park, Ont.; W. B. Greenwood and A. P. MacBean, North Bay, Ont, for facilitating field work; D. W. Gray, Ontario Forestry Branch, Toronto, for help in computations; A. C. Cline and N. W. Hosley, Harvard Forest, Petersham, Mass., and M. A. Adamson, Midhurst, Ont., for records of sporulation; D. W. Hamly for photomicrographs acknowledged under "Explanation of Plates"; the J. R. Booth Company, Egan Estate, Ont., and the Carpenter-Hixon Company, Blind River, Ont., for assistance in the field; the Bliss Foundation, Harvard University, and the Ontario Forestry Branch for financial assistance.

ADDENDA

1. Plot Description

The plots referred to herein, on which tree examinations were made, were located in the eastern part of Algonquin Park, Ontario in young even-aged white pine. The stands had never been disturbed by man, and represented phases of entirely natural forest development. The plots were in two groups, the first near Bissetts, comprising four plots of one-tenth acre each, the second near Achray, comprising three plots of one-fortieth acre each. On each plot all trees were felled, the trunks cut into four foot lengths (or shorter) and all sections were split. The roots were exposed and cut, and the stumps grubbed out.

The plots in which trees infected by *Trametes Pini* were found, originated following a widespread fire which swept through the virgin forest stands about sixty years ago. These stands were then mature, and comprised many pines of the largest size, of which a considerable number survived the fire for at least several years, and cast seed sufficient to restock satisfactorily much of the area burned over. All such survivors, however, have now been dead for many years, though occasional giant chicots still remain standing. These and the numerous large well-rotted trunks on the ground offer evidence as to the character of the former forest. The following table gives the mean (arithmetical average) age, D.B.H., and total height of the dominant and co-dominant white pines on the several plots; also the number of living white pines of all classes, expressed per acre.

Plot No.	Age	D.B.H. inches	Total Height feet	No. of living Pines (all classes) per acre
1	50	7.0	44.5	420
2	53	7.4	49.0	420
4	51	5.6	41.2	720
5	51	4.9	37.1	1320

Plot No. 1 Bissetts

The forest is predominantly of white pine, with some spruce, balsam, white birch and poplar. The most conspicuous herbage is of *Pteridium aquilinum*, *Aster macrophyllus*, *Cornus canadensis*, and *Vaccinium canadense.*

The remains of very large pines (30″ – 40″ D.B.H.) are on the ground. One large trunk (40″ D.B.H.) lying across the plot, riddled with *Trametes Pini* rot, scarred a number of young trees of the new stand in falling 25 years ago.

Plot No. 2 Bissetts

Plot No. 2 represents an area of almost pure pine, on a site similar to that of Plot No. 1. Considerable weeviling has occurred in the past. The well-rotted trunks of large pines of the parent stand are lying adjacent to the plot.

Plot No. 4 Bissetts

The stand here represented was established very densely, but subsequent fire, occurring about 45 years ago, thinned it out leaving rather uneven, though still dense stocking. The pines are now crowded in groups, among which there is a good representation of poplar and birch and a few maples. The site is possibly somewhat inferior to that of No. 1 and No. 2.

Plot No. 5 Achray

This plot represents a stand established densely on sandy soil between numerous rock outcrops. The site is inferior to any of the above. A rather severe fire nineteen years ago burned over much of the surrounding country, but barely touched the pocket in which this plot is located.

2. TABLES

Explanation of symbols used in tables.

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Explanation of symbols used in tables.

Tree Class

D. —dominant
C.D.—co-dominant
I. —intermediate
S. —suppressed

Rot Stage

R.R.—red rot
A. —advanced rot
E. —early rot
W.P.—white pocket rot

Rot Type

T.P. —*Trametes Pini* rot
F.T. —a butt rot
S.P. —a wood stain
G.S. —a wood stain
F.B.B.R.—a brown butt rot
U.B.R. —a brown trunk rot
A.M. —*Armillaria* rot

Infection Court

K. —branch stub (with "punk knot")
K —branch stub (with no "punk knot")
? —unknown (probably branch stub)
FS —fire scar
W —wound
WT —weeviled top
S —large stub, still projecting
R —root
B —base of stump, immediately under vertical axis of tree

NOTE:

Under the heading "Rot Extent," the distances in feet from the ground to the extremities of the decay are given. The maximum diameter of the obviously decayed wood is given in inches.

Example: "Rot extent = 19'-21' x 0.75". The rot extends from a point 19 feet above ground to one 21 feet, and the maximum diameter of the decay is 0.75 inches.

TABLE 1. Basic Data on *Trametes Pini* Infected Trees in Plots

Plot No. 1 Bissetts.

Tree No.	Class	Stump Age	D.B.H.	Total Height	Rot Type	Infection Court	Infection Location	Rot Extent	Rot Stage
1	D.	53	7.5	48.0	TP	K.	20.5′	19′-21′ x 0.75″	E
7	I.	49	4.6	29.4	TP	K.	12.5′	12-12.5′ x 0.5″	E
9	C.D.	51	5.8	48.6	F.T.?	?	?	0.25′-0.75′ x 1″	
					T.P.	K.	13.5′	12′-17′ x 3″	RR
17	D.	53	9.0	53.0	TP	K.	5′	3′-7.5′ x 1.5″	E
					TP	K.	4′	0.5′-6.0′ x 2.0″	E
(Appear to be separate infections.)									
19	I.	46	6.5	45.0	TP	K	0.5′	0′-3′ x 0.5″	E
(No "punk knot" found, but knots at 0′-1′ gummy.)									
22	C.D.	48	6.2	39.5	TP	K.	17.0	15′-18′ x 0.75″	E
27	C.D.	48	6.8	44.2	SP	?	?	-0.8′ x 1.0′ x 0.5″	
					GS	W	1.5′	0.5-5.0 x 1.5″	
					TP	K.	13′	11′-15′ x 1.0″	RR
(Tree scarred from 1.0′ to 3′.0′ - open.)									
30	C.D.	52	7.1	43.6	TP	K	0.5′	0′-1′ x 0.5″	E
(No "punk knot" found. Infection probably at 0.5′.)									
34	D.	50	7.5	57.8	TP	K.	2.5	0-5′ x 1.0″	RR
39	C.D.	54	7.1	45.5	SP	W	4.5?	-2.0′-4.5′ x 4″	
					TP	K.	14.5	14.0′-15.5′ x 1.5″	E
42	I.	53	7.0	45.5	TP	K.	0.5	-0.5′-6.0 x 3″	RR
							1.0		
							1.5		
						K.	3.5		
(Probably two separate infections at 1.0′ and 3.5′.)									
46	C.D.	51	7.5	45.0	TP	W	1.0′	1′-7′ x 2.5″	RR
					TP	W	9.5′	8.2′-10.5′ x 3.0″	WP
					TP	K	18.0′	17′-19.5′ x 1.5	E
(Tree scarred by 40″ D.B.H. pine chicot falling 25 years ago. Open scars 8.5′ to 9.5′ and 2′ to 4′. *Trametes Pini* fructification ½″ x ½″ on wound at 9.5′. No "punk knots" formed as yet.)									
48	I.	52	4.4	41.0	TP	W	1.0′	0.5′-7.0′ x 1.5″	RR & WP
					TP	W	14.0″	11′-20′ x 1.0″	RR & WP
					SP	B	-0.5	-2-0.5 x 3.0″	
(Tree scarred by same tree as No. 46, from 2′ to 3.5′, 15′ to 15.3′ and 18′-18.2. No "punk knots".)									

Table 1—Continued

Plot No. 2 Bissetts.

Tree No.	Class	Stump Age	D.B.H.	Total Height	Rot Type	Infection Court	Infection Location	Rot Extent	Rot Stage
10	C.D.	53	7.5	47.0	TP	K.	6.0′	2.5′-8.5′ x 1.5″	RR
					TP	WT	13.0′	8.5′-16.5′ x 2″	RR
(Top weeviled 36 years ago. Dead end ½″ diam. barely covered now.)									
11	D.	55	9.9	49.5	TP	K.	4.5′	3.0′-8.5′ x 1.5″	RR
					TP	WT	17.0′	16′-18′ x 1.0″	RR
					UBR	S	15.5′	14′-15.5′ x 2.0″	A
22	D.	50	7.2	50.5	TP	K	2.0	0.5′-4.0′ x 0.5″	E
					TP	K	9.5	9′-10′ x 0.25″	E
30	D.	54	8.8	43.3	TP	?	2.0′?	-0.5′-4.0′	E
31	C.D.	55	7.3	45.3	TP	K.	0.5′	-0.5′-1.5′ x 2″	RR
					AM	R	?	-1.0′-0.0′ x 2″	A
(TP infection through ¼″ stub.)									
41	D	53	5.4	46.5	TP	K.	1.0′	-0.5′-4.0′	E

Plot No. 4 Bissetts.

Tree No.	Class	Age	D.B.H.	Total Height	Rot Type	Infection Court	Infection Location	Rot Extent	Rot Stage
1	D.	54	6.9	42.8	TP	K.	2.0′	0′-8′ x 4″	WP
					FBBR	FS	?	-1.0′-2.5′ x 2″	
(T.P. ring and heart-rot. Covered fire scar on butt made 44 years ago.)									
7	I.	48	5.8	35.5	TP	K.	1.5 1.8 2.0	-0.5-8.0′ x 4″	A
("Punk knots" very large (1″ diam.). Rot becoming dry.)									
20	S.	42	3.1	27.5	TP	K.	1.0	0.0-4.0′ x 1″	RR
23	D.	54	5.3	45.5	TP	WT	4.5′	3.5′-4.5′ x 1″	E
(Weeviled top completely buried 24 years ago.)									
34	C.D.	53	5.3	35.0	TP	K.	1.5 2.5 3.0	0.0′-5.5′ x 1″	RR
(Fire scarred 44 years ago, but infected through branch stub on opposite side. "Bull grain" in callus over wound starts 25 years ago.)									
37	C.D.	49	4.3	41.0	TP	?	?	0.0-0.5′ x 0.5″	E
60	S	51	3.4	36.5	TP	K	4.5′	4.2′-4.6′ x 0.25″	E
73	S	45	2.1	25.0	TP	K.	1.0′ 2.0′	0.0′-5.0′ x 1.5″	RR

Plot No. 5 Achray.

Tree No.	Class	Stump Age	D.B.H.	Total Height	Rot Type	Infection Court	Infection Location	Rot Extent	Rot Stage
18	D.	53	4.4	39.0	TP	W	1.5	0.5′-1.8′ x 1.0″	E
19	D.	64	7.4	43.0	TP	K.	1.5	-1.0′-5.0′ x 3″	RR
					TP	WT	4.5	-1.0′-5.0′ x 3″	
(Tree growing on top of uprooted pine stump, elevated 2′. Two separate T.P. infections.)									
26	C.D.	53	4.7	37.0	TP	K.	3.0′	0.0′-0.8′ x 0.5″	E
(Infection through 1/20″ twig.)									

TABLE 2. *Trametes Pini* Infection in Relation to Tree Class (Plot Trees).

(Number of Living Sound and Infected White Pine Trees on Infected Plots.)

Class	Plot No. 1		Plot No. 2		Plot No. 4	
	No. of Trees Sound	Infected	No. of Trees Sound	Infected	No. of Trees Sound	Infected
Dominant and co-dominant	12	9	17	6	24	4
Intermediate	10	4	10	0	10	1
Suppressed	7	0	9	0	30	3
Total	29	13	36	6	64	8

Class	Plot No. 5		All Plots		
	No. of Trees Sound	Infected	No. of Trees Sound	Infected	Per Cent Trees Infected
Dominant and co-dominant	13	3	66	22	25
Intermediate	8	0	38	5	12
Suppressed	9	0	55	3	5
Total	30	3	159	30	16

TABLE 3. *Trametes Pini* Infection Courts in Young Pine.

(Frequency of Courts of Various Kinds, and Position on Trunk).
(Data from Plots).

Description of Court	*Frequency and Location* *(Distance in feet above ground)* Below 2′	2′-4.5′	4.5′-14′	Above 14′	Total	Per Cent	
K.	8	6	5	3	22	57	77
K	2	2	1	1	6	15	
?	1	1	0	0	2	5-	
W	3	0	2	0	5	13	23
WT	0	2	1	1	4	10	
Total	14	11	9	5	39	100	
Per cent	36	28	23	13		100	

TABLE 4. Seasonal Sporulation of *Trametes Pini* at Petersham, Mass.

Sporophore No.	1931 July	Aug.	Sept.	Oct.	Nov.	Dec.	1932 Jan.	Feb.	March	April	May	June	July	Aug.
1	-000	0000	0000	0020	0-12	00	Discontinued							
2	-000	0000	0000	0000	0000		Discontinued							
3	-300	0023	3333	0022	2-12	00—	-200	00--	0---	——	1--0	-0--	4---	2---
4	-000	0003	2244	3344	4443	00—	-3—	00--	0---	——	1--0	-0--	3---	1---
5	-000	0003	3444	3344	4444	00—	-4—	00--	0---	——	3--4	-4--	----	1---
6	-000	0000	0233	2222	222-	Discontinued								
7					4-	00-4	-400	00--	0---	13—	3--4	-4--	4---	4---
8					4-	0—2	-200	00--	0---	11—	3--3	-0--	4---	1---
9					—	—2	-200	00--	0---	-1—	3--0	-0--	4---	4---

Key:
0—No spore cast.
1—Spore cast very light.
2—Spore cast moderate.
3—Spore cast heavy.
4—Spore cast very heavy
—No report

TABLE 5a. Frequency of Sporophores of *Trametes Pini* on Living Pines.

Locality	No. of Trees Examined	Age Range	No. of Trees Infected	No. of Trees bearing Sporophores	Total No. of Sporophores
1	253	30-64	30	1	1
2	131	30-65	?	0	0
3	1263	50-65	4+	4	5
4	80	50-65	4+	0	0
5	200	90 (approx.)	3+	3	3
6	52	145 (approx.)	30+	12	19+
7	100	130-150	42+	5	8+
8	90	88-150	44	0	
9	26	201-296	21	0	
10	32	235-429	26	0	
11	67	200-225	40	1	1
12	13	150-350	13	2	4
Total	2307		257+	28	41+

Key to Localities:

1 - Sample Plots, Algonquin Park, Ont.
2 - Achray, Algonquin Park, Ont.
3 - Near Achray, Ont.
4 - Durham Forest, Durham County, Ont.
5 - Walsh, Simcoe County, Ont.
6 - Tilden Lake, North Bay District, Ont.
7 - Little Nipissing River, Algonquin Park, Ont.
8 - J. R. Booth Co., Camp No. 3, Algonquin Park, Ont.
9 - J. R. Booth Co., Camp No. 2, Algonquin Park, Ont.
10 - Carpenter-Hixon Co., Camp No. 28, Algoma, Ont.
11 - Carpenter-Hixon Co., Camp No. 26, Algoma, Ont.
12 - Ranger Lake and Little Garden River, Algoma, Ont.

TABLE 5b. Occurrence of Sporophores of *Trametes Pini* on Infected Trees.

Locality	Age of Tree	D.B.H.	Area of Pore Surface (sq. inches)	Ht. of Sporophore Above Ground (feet)	Locus of* Sporophores
1	51	7.5	0.75	9.5	Old scar
3	58	7.5	0.25 (D)	4.5	Punk knot
			0.25 (D)	4.5	" "
	62	9.3	0.12	8.0	Stub
	65	12.0	0.50	4.5	Punk knot
	52	6.4	0.05	5.5	Stub
5	90 (approx.)	13.5	2.0	1.0	Punk knot
	90 "	16.0	0.50	16.0	" "
	90 "	12.0	3.0	8.0	" "
6	145 (approx.)	22.0	0.12	8.0	On stub
	"	9.0	0.25	8.0	" "
				9.0	" "
			2.0 (Group)	9.0	" "
			2.0 (Group)	12.0	" "
	"	23.0	3.0	8.0	Punk knot
	"	26.0	0.05 (D)	5.0	On stub
			0.05 (D)	6.0	" "
	"	14	0.5	10	Punk knot
	"	15	2.0	9	Stub
	"	13	0.05	10	"
	"	22	1.5 (D)	12	"
	"	25	6.0 (D)	1.5	"
	"	28	0.05	3.0	Punk knot
			0.05	6.0	Stub
	"	†15	6.0	2	Punk knot
			6.0	2	Stub
			20.0 (Group)	0 to 8	Bark
		16	3.0 (D)	8	Stub
7	140	20	5.0	8	Stub
			5.0 (D)	40	"
	138	19.5	2.0	40	"
	130	11	2.0	6	Punk knot
			2.0	7.5	Stub
	140	14	10.0 (Group) (D)	6 to 7	Punk knot
	135	17	8.0	2.5	" "
			0.75	5.5	" "
11	215	22.2	2.0	45	Stub
12	230	20.5	1.5	7	Punk knot
			0.25	7.2	" "
	200	11.7	0.05 (D)	25.0	Stub
			0.05	25.0	"

†—Tree dying.
D—Sporophore dead.
*—Sporophores on "stub" are attached directly to wood of stub.
Sporophores on "punk knot" are attached to bark, the stub having been buried by growth.

TABLE 6. Frequency of Sporophores of *Trametes Pini* on Cull Logs and Windthrown Timber.

Locality	Age of Cut (yrs.)	No. of Logs Examined	No. of Logs Bearing Sporophores	No. of Sporophores Per Log
Lynx Lake (Algonquin Park, Ont.)............	1	22	9	1-9
Lynx Lake..............	2	8	7	2-L
Lynx Lake	3	13	10	1-LL
Tilden Lake (North Bay District, Ont.).........	8	12	10	2-L
Durham Forest (Simcoe County, Ont.)..........	10	9	4	1-9
Phillip's Depot (Algonquin Park, Ont.)............	20	10	3	1-2
McPhee Lake (North Bay District, Ont.).........	18 yr. old burn	12 trunks	7	1-12

L—A great many.

TABLE 7. Frequency of Infected Trees in Timber Stands

Locality	No. of Trees Examined	No. of Trees Rotted by			
		T.P.		C.R.	
		No.	Per Cent.	No.	Per Cent.
J.R.B. No. 8.........	90	44	49	30	33
Carp.-Hix. No. 26.....	67	40	60	32	48
J.R.B. No. 2.........	26	21	81	14	54
Ranger Lake.........	13	13	100	10	77
Carp.-Hix. No. 28.....	32	26	81	30	94

T.P.—*Trametes Pini* Rot, typical form.
C.R.—Cavity Rot.

TABLE 8. Classified Rot Volumes.
(Figures = cubic feet.)

Locality (see table 5a)	No. of Trees (Basis)	Volume of Trees (1)	Volume of dead Cull Logs	Rot Volume: T.P.	Rot Volume: C.R.	Rot Volume: T.P. and C.R.	Rot Volume: Other Rots	Total Rot	Cruise Cull (2)
8.	90	2690.1	407.6	129.9	39.9	169.8	96.6	266.4	477.8
11.	67	5773.6	968.6	643.1	192.9	836.3	112.6	948.9	1344.3
9.	26	2488.2	955.4	320.8	177.3	498.1	143.3	641.4	1120.8
12.	13	1134.4	420.6	182.2	37.5	219.6	92.5	312.1	565.6
10.	32	6875.3	2133.8	961.1	578.7	1539.8	435.7	1975.5	2966.0

(1)—From stump to top cut.
(2)—Total volume of dead cull logs plus volume of rot in other logs.

TABLE 9. Classified Rot Volumes.
(Figures = per cent.)

Locality (see table 5a)	No. of Trees (Basis)	Total Volume of Trees	Total volume of Dead Cull Logs	Total Volume of Rot	Volume of each kind of rot per cent. of Total Rot: T.P.	C.R.	T.P. and C.R.	Other Rots
8.	90	100	15	9.9	49	15	64	36
11.	67	100	17	16.4	68	20	88	12
9.	26	100	38	25.8	50	28	78	22
12.	13	100	37	27.3	58	12	70	30
10.	32	100	31	28.7	49	29	78	22

TABLE 10. Classified Rot Volumes.
(Rot Expressed as Percentage of Total Volume Cut)

Locality (see table 5a)	No. of Trees (Basis)	T.P.	C.R.	T.P. and C.R.	Other Rots	Total	Cruise Cull Per Cent.
8.	90	4.8	1.5	6.3	3.6	9.9	17.8
11.	67	11.1	3.3	14.4	2.0	16.4	23.3
9.	26	12.9	7.2	20.1	5.6	25.8	45.0
12.	13	16.0	3.3	19.3	7.9	27.3	49.9
10.	32	14.0	8.4	22.4	6.3	28.7	43.1

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4. EXPLANATION OF PLATE 1.

(Photo-micrograph figs. 5-13 by Dr. D. H. Hamly, University of Toronto.)

Fig. 1. Pore surface, *Trametes Pini*, from white spruce. (x-8.6).

Fig. 2. Pore surface, *Trametes Pini*, from Douglas fir. (x-8 6).

Fig. 3. "Punk knot" in white pine caused by *Trametes Pini*. Tree No. 1. Plot No. 4. (x-0.2).

Fig. 4. Surface lesion caused by *Trametes Pini* radiating from a "punk knot" on trunk of white pine. The bark has been freshly peeled. "Bull grain" wood, "punk knot" substance and resin flow are conspicuous. (x-0.2).

Fig. 5. Transverse section through margin of "punk knot" at cambial region in white pine. "Punk knot" substance at upper right. Living phloem (with dying cells interspersed) at lower left. Cavities in the phloem are resin filled. (x-70).

Fig. 6. Transverse section through cambial region in white pine at periphery of "punk knot". Specimen collected in the fall. Hyphae massed on face of wood, and occurring intracellularly in tracheids. Phloem largely disorganized. Traceid at lower left isolated in necrotic phloem. (x-300).

Fig. 7. Radial section through sapwood of white pine invaded by *Trametes Pini* from beneath. The tracheids shown are 2.57 mm. from the cambium. Hyaline hyphae, thick-walled hyphae, modose hyphae, and sclerotioid bodies are present. (x-300).

Fig. 8. Tangential section through "bull grain" sapwood of white pine. Hyphae in tracheids are appressed to nucleated ray cells, and have invaded necrotic cells shown in centre. (x-214).

Fig. 9. Tangential section through "bull grain" wood of white pine showing inflated ray cells. (x-214).

Fig. 10. Tangential section through "bull grain" wood of white pine showing inflated ray cell with nucleus, blocking tracheid. (x-214).

Fig. 11. Tangential section through "bull grain" wood of white pine showing tyloses. (x-214).

Fig. 12. Tangential section through "bull grain" wood of white pine showing tyloses and segmentation of tracheary elements. (x-214).

HADDOW—THE DISEASE CAUSED BY *TRAMETES PINI* (THORE) FRIES IN WHITE PINE (*PINUS STROBUS L.*)

A STUDY OF THE HELMINTH PARASITES OF LAMBS IN ONTARIO

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Introduction

The present study of the helminth parasites of lambs aims to treat the problem from several standpoints: the distribution of parasites within the host, the degree of infestation with various kinds and their seasonal variation, and also the geographical distribution of the different species in the area from which the lambs came.

Acknowledgments

The writer wishes to thank Professor E. M. Walker, Head, Department of Biology, University of Toronto, and Dr. Seymour Hadwen, Director of Pathology and Bacteriology, Ontario Research Foundation, under whose direction this work was carried out. Their suggestions and constructive criticism made during the study have been of value and are much appreciated.

The funds and facilities for carrying out the investigation were provided by the Ontario Research Foundation through the kindness of its director, Dr. H. B. Speakman, to whom thanks are also due for his encouragement and kindly advice.

The valuable assistance of these men together with that of Professor J. R. Dymond, Director, Royal Ontario Museum of Zoology, and other members of the staff of the Department of Biology, in the preparation of the manuscript is also much appreciated.

I. Materials and Methods

The lambs, on which the present studies were based, were selected at random at a Toronto abattoir from shipments received from known localities. Material obtained from one hundred and forty-four lambs formed the basis of this study.

The viscera of two or three of these were examined each week for a period of 15 months from April, 1935, to August, 1936. This was fresh material taken at the time of slaughter and sent at once to the laboratory. The ages of the animals were, with one or two exceptions, one year old or less.

The viscera were placed in a large sink in the laboratory and there the heart, liver and lungs were separated from one another and from the

alimentary tract. Each was examined externally for the presence of worm nodules and then cut open and examined internally for parasites. The nodules were crushed and examined between glass plates in many cases, although generally the presence or absence only of the nodules was noted without any microscopic examination.

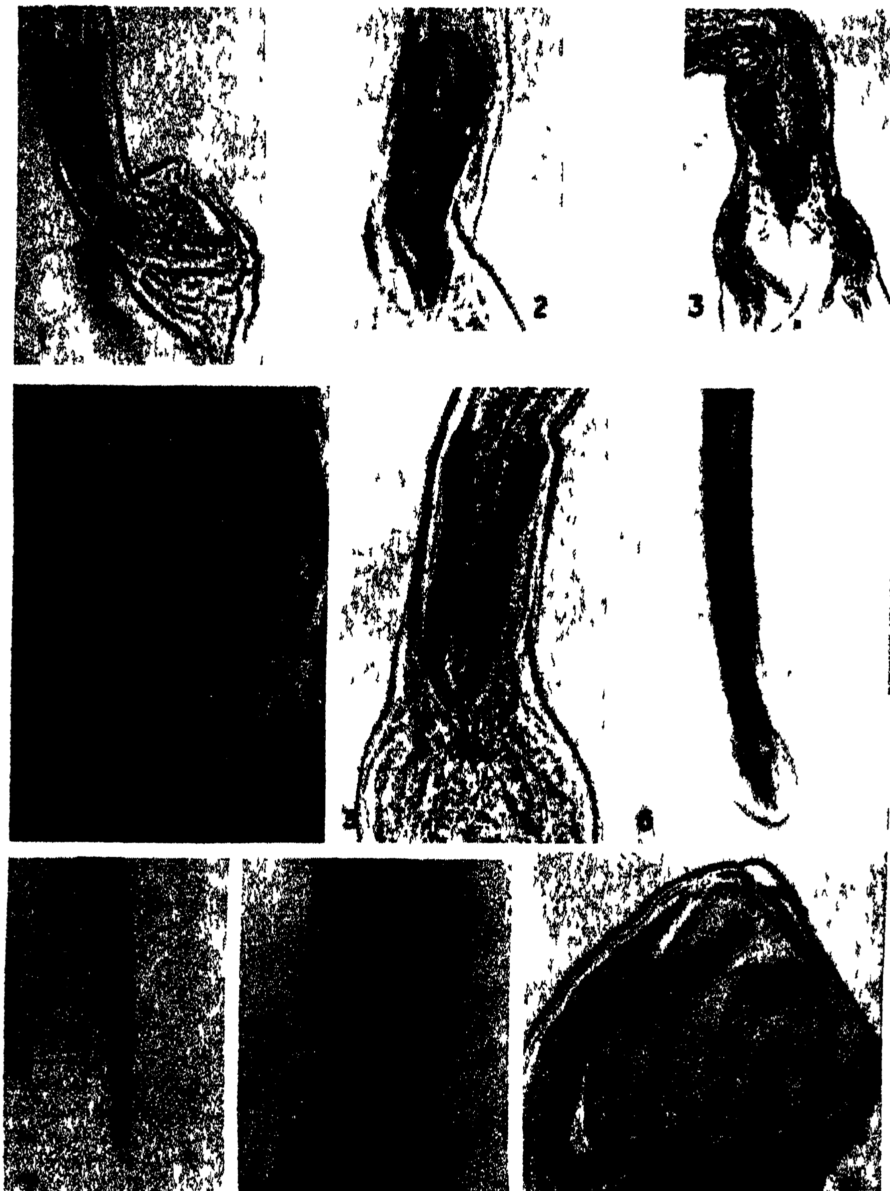
It was pointed out in the introduction that the study was concerned with the helminth parasites, so that whenever the term "parasite" is used in the present paper it is meant to refer to the worm parasites.

The abomasum was next separated from the intestine and opened from end to end. The contents were washed with running water, through a 60-mesh brass screen, until free of all colouring material and debris which passed through the screen. The lining mucosa of the abomasum was washed thoroughly and examined for lesions. The contents of the abomasum remaining on the screen were diluted up to 1,000 cc. with water, in a 3-litre glass jar, then while constantly agitating to distribute the worms as uniformly as possible throughout the liquid, 50 cc. were removed with a wide-mouthed pipette (12 mm.) and a few drops of formalin were added. All the worms in this 50 cc. sample were counted and multiplied by twenty, giving an approximation of the number of worms in the entire sample. This dilution method is approximately that described by Taylor (1934)[1] for diagnosing parasitic gastritis in sheep. It is realized there may be a considerable error in counting such a small part of the litre. But, owing to the large amount of material which was usually present in a lamb's stomach it was found impracticable to count all the worms in it. The larger worms could be counted with the naked eye, but a low power binocular (30x) and a petri dish which had been ruled into squares were used for counting the smaller ones.

The small intestine, which is approximately one hundred feet long in lambs, was examined by tying it off in two-foot lengths, beginning at the pylorus, and washing each of these separately in order to determine the distribution of the worms within the gut. When not concerned with the actual habitat of the worms the separation was in ten-foot lengths only. A few examinations revealed that the majority of the parasites, excepting the tapeworms, were found in the proximal 50 feet of gut. Subsequently, the more distal portion was examined only for tapeworms.

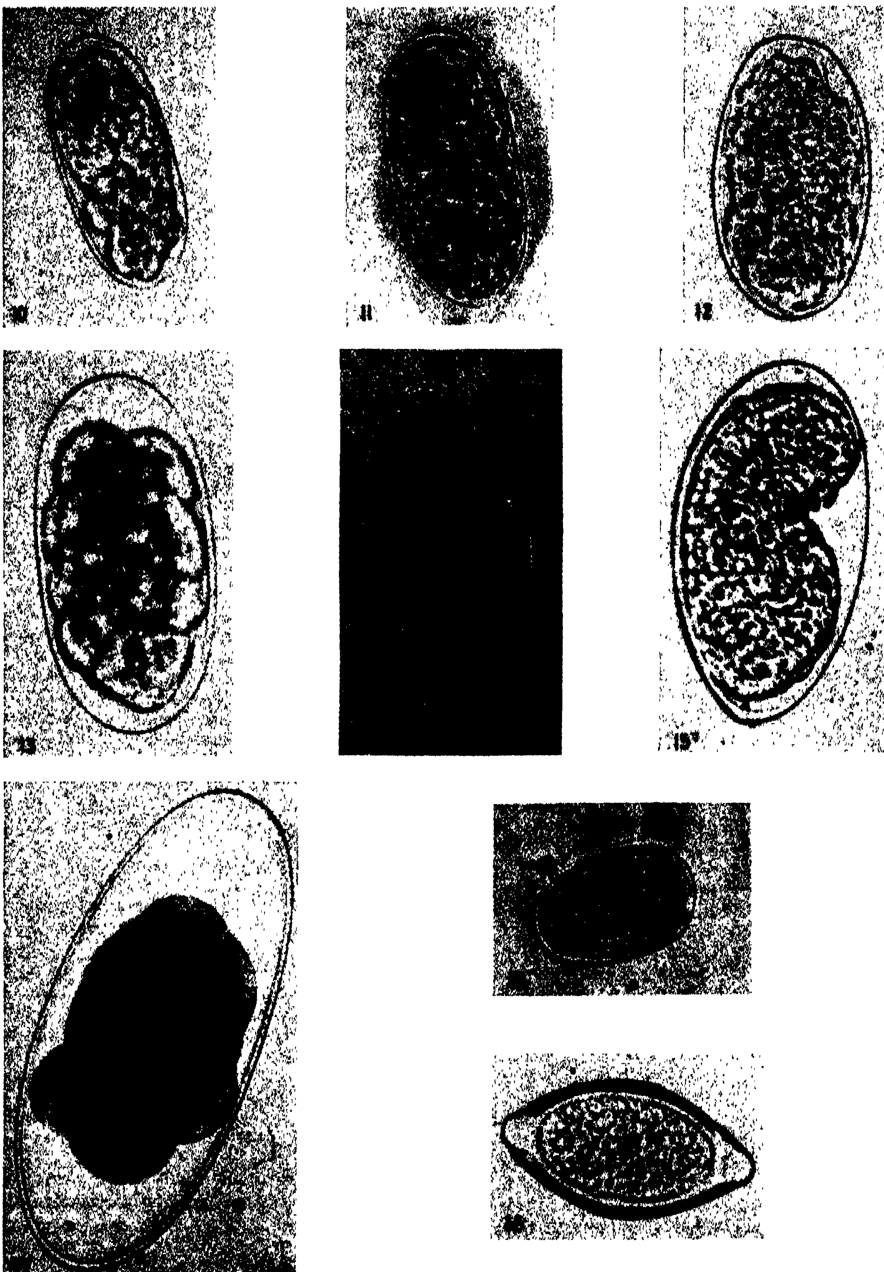
The nematodes tend to attach themselves to the intestinal wall and may even remain attached when the viscera have cooled to room temperature. This precludes the possibility of any extensive movement of the nematodes following the removal of the viscera from the lamb, with the possible exception of immature specimens of *Ascaris* sp. which were found in two animals.

The technique for examining the intestinal contents was similar to



Figs. 1-8. Photomicrographs showing spicules of various nematodes. 1. *Trichostrongylus extenuatus* x 260; 2. *T. colubriformis* x 260; 3. *T. vitrinus* x 105; 4. *Cooperia oncophora* x 260; 5. *C. curticei* x 260, 6. *Nematodirus spathiger* x 105; 7. *N. filicollis* x 105; 8. *Ostertagia circumcincta* x 105.

Fig. 9. *Bunostomum trigonocephalum*; Buccal cavity



Figs. 10-18. Eggs of various nematodes. 10. *Cooperia curticei*; 11. *C. oncophora;* 12. *Haemonchus contortus*; 13. *Chabertia ovina*; 14. *Trichostrongylus vitrinus*; 15. *Ostertagia circumcincta*; 16. *Strongyloides papillosus*; 17. *Nematodirus spathiger*; 18. *Trichuris ovis.*
Fig. 17 is x 420, all others x 580, but entire plate was reduced 20% in reproduction.

that described for the abomasum except that in many cases all the worms in the sample were counted and Taylor's dilution method was not necessary.

The caecum was examined in a similar way and all the worms which were adhering to the wall of the gut were counted.

In the case of the large intestine the proximal half was examined and the latter half discarded. The parasites in the entire sample were counted.

No attempt was made to obtain a mathematical estimate of the error involved in counting the worms. It would differ in each case depending on the amount of debris which was left with the parasites. Moreover, the error would not be the same for all kinds of parasites as there was a much greater chance of overlooking the smaller forms among the debris than the larger ones. Experience and care in counting would reduce it to a minimum.

The term "infection" as used throughout this paper refers to the presence of parasitic worms rather than to parasitic bacteria or a combination of the two.

II. IDENTIFICATION OF SPECIMENS

The nematodes were identified with the assistance of the descriptions and keys given in Baylis (1929), although Mönnig (1934), and Yorke and Maplestone (1926) were consulted frequently. A paper by May (1920) and one by Price (1927) were useful for the identification of species of *Nematodirus*.

The genera, although not all species, could be separated under low magnification. Consequently, the species present were determined, although the numbers of each were not, with the result that the geographical distribution and incidence of infection with the various species were found but not the degree of infestation with each.

The characters of some species which are useful in separating them are illustrated in figures 1-9. The spicules of three species of *Trichostrongylus* are shown in figures 1-3. The difference in their length is apparent. The one spicule longer than the other in *T. extenuatus*, the barbed tips to those of *T. colubriformis* and the pointed tips of *T. vitrinus* are also shown. The difference in the size and character of the spicules in the species of *Cooperia* and *Nematodirus* can be seen in figures 4-7. The typical spicules of *Ostertagia circumcincta* are shown in figure 8 and the characteristic dorsal tooth in the buccal cavity of *Bunostomum trigonocephalum* in figure 9.

III. METHOD OF DIAGNOSING INFESTATION

The usual method of diagnosing parasitic infection is by finding the eggs of the parasite in the faeces. It was pointed out by Hall (1923) and Wood (1931) that infestation with all species of sheep parasites could not be decided by the size of the eggs alone. Dikmans and Andrews (1933) made a morphological study of the infective larvae of a number of sheep parasites and concluded that diagnosis based on larval characters is difficult. It was thought a careful study of the shape of the eggs of the different species, considered along with their size, might assist in diagnosis. It will be apparent from an examination of figures 10-18 that infection with all species cannot be determined by this method as the eggs of many are too much alike in size and shape. The lateral walls of the eggs of *Cooperia* (figures 10-11) are more nearly parallel than some of the others although their size is almost identical with those of *Haemonchus* (figure 12). *Chabertia* eggs (figure 13) tend to have parallel sides also and although they are a little larger than those of *Haemonchus* the two kinds might be confused. The more pointed ends of *Trichostrongylus* eggs (figure 14) help to distinguish them but there is some similarity between these and those of *Ostertagia* (figure 15). The eggs of *Strongyloides* (figure 16) can be recognized because they are smaller than any of the others, and the large size of the eggs of *Nematodirus* (figure 17) is characteristic. The typical "plugs" at the ends of the *Trichuris* egg (figure 18) leaves no doubt as to its identity.

Stoll (1923) devised a method for estimating the number of hookworms in an animal by counting the number of eggs in the faeces. The method has since been usefully applied to other species. It cannot be used for finding the degree of infestation of a lamb with parasites when several kinds are present because of the similar appearance of the eggs of many. Instead it is necessary to study the degree of infestation by counting the number of parasites present.

IV. OCCURRENCE AND RELATIVE ABUNDANCE OF SPECIES

List of species

Nineteen species of helminths belonging to fifteen genera have been taken from one hundred and forty-four animals examined. They are listed below:

Class—Cestoda

Moniezia expansa

Class—Nematoda

Ascaris sp.
Strongyloides papillosus

Oesophagostomum columbianum
Chabertia ovina
Bunostomum trigonocephalum
Dictyocaulus filaria
Muellerius capillaris
Trichostrongylus vitrinus
" *colubriformis*
" *extenuatus*
Cooperia curticei
" *oncophora*
Ostertagia circumcincta
Haemonchus contortus
Nematodirus spathiger
" *filicollis*
Trichuris ovis
Capillaria sp.

V. DEGREE OF INFESTATION

The frequency and severity of infestation with the different genera of worms is given in table 1. This table is based on the results of the examination of 129 lambs since the parasites from the first 15 animals were not separated quantitatively into the various genera. Parasites were found in each of the 144 animals. A minimum of fifty worms was taken from one lamb while the maximum obtained was 22,788. The average number per animal, based on the results of 144 examinations, was 4,296.

The mass of the parasites found in different lambs is quite variable, depending on whether tapeworms are present or not, for the nematode parasites are small in comparison. As much as one-half litre or more of tapeworms was sometimes taken from a single lamb, and although hundreds of nematodes may be present they occupy only a small space. Large numbers of some of the small nematodes are known to be pathogenic, whereas the degree of pathogenicity of the tapeworm is still unknown.

The genera found most commonly were *Ostertagia*, *Trichostrongylus*, *Nematodirus* and *Cooperia*, all of which were present in over 80 per cent. of the animals. *Haemonchus* although an important parasite in many countries, was found in only 60 per cent. of the lambs. This worm showed a marked seasonal variation in numbers which may partly account for the lower figure obtained. A rather high percentage of animals was infected with some of the other genera, e.g. *Trichuris* and *Chabertia*, but they were seldom present in large numbers.

TABLE 1

INFESTATION WITH DIFFERENT GENERA OF PARASITES, BASED ON EXAMINATION OF 129 ANIMALS

Kind of Parasite	No. of Animals Infected	% Infected	Av. No. of Worms per Animal	Av. No. of Worms per Infected Animal	Minimum and Maximum No. of Worms per infected Animal
Haemonchus ...	79	60.3	235	383	20—5,200
Ostertagia	106	82.2	546	667	20—4,400
Trichostrongylus in Abomasum...	106	82.2	1,272	1,548	20—10,940
Trichostrongylus in Intestine...	119	92.3	696	756	1—8,631
Strongyloides	121	93.8	225	240	1—1,673
Nematodirus	113	87.6	582	672	1—10,136
Cooperia	122	94.6	487	518	1—9,471
Bunostomum	49	37.4	6	16	1—154
Moniezia	35	26.7	18	65	1—938
Oesophagostomum nodules	53	40.4	...	...	....
Oesophagostomum worms	44	33.5	2	6	1—42
Trichuris	87	66.4	14	21	1—461
Chabertia	88	67.1	21	31	1—338
Muellerius	55	42.6	...	...	....
Dictyocaulus	1	0.8	...	...	....
Ascaris	2	1.3	...	...	....

TABLE 2

SHOWS THE NUMBER AND PERCENTAGE OF 129 LAMBS INFECTED WITH DIFFERENT NUMBERS OF GENERA

No. Genera of Parasites	No. of Animals Infected	Percentage of Animals Infected
3	1	0.8
5	6	4.8
6	17	13.0
7	21	16.0
8	24	18.3
9	35	26.1
10	18	13.7
11	6	4.6
12	1	0.8

Average number of genera of parasites harboured by a single animal was 8.

In view of the seasonal variation in numbers of some parasites, to be discussed later, a misleading result might be obtained if the animals were examined at only one season.

Some genera were represented by more than one species. The number of individuals of each of these species was not counted for reasons stated in the paragraph on identification although they were identified in order to get the incidence of infection, together wtih their geographical distribution. The frequency of occurrence was found to be as follows: *Trichostrongylus colubriformis* in 46.5% of the lambs; *T. vitrinus* in 35.6%, and *T. extenuatus* in 28.1%. A mixed infection with *T. vitrinus* and *T. colubriformis* occurred in 10.3%; with *T. vitrinus* and *T. extenuatus* in 8.2%; with *T. colubriformis* and *T. extenuatus* in 8.9% of the cases; and all three species were present in 2.7% of the cases. In 16.4% of the lambs the trichostrongyles were identified only as to genus.

Cooperia curticei was present in 64.4% of the animals; *C. oncophora* in 22.6%, and there were 8.2% in which identification was not made to species.

Nematodirus filicollis was recovered from 39.5% of the lambs, and *N. spathiger* from 24.7%, and the specimens obtained from 9.6% were identified only as to genus.

Haemonchus contortus, which is known to be of pathogenic significance, was not found in very large numbers except in animals examined in late summer.

A summary of the number of genera harboured by the different animals is given in table 2. The smallest number ever present was three, the largest twelve and the average eight, but it will be noticed that the largest percentage of the animals was infected with nine genera.

The degree of infestation of animals received from different localities in the province was quite variable and no correlation could be established between environmental conditions outside the host in the different localities and the degree of infestation of the animals. This has been done to quite an extent in Australia (Ross and Gordon, 1936), where the degree of infestation has been correlated with rainfall. The differences in rainfall in different parts of Australia are much greater, however, than in Ontario. This province also differs from Australia in that the temperature here for two or more months of the year is usually well below freezing, which factor may affect the degree of infestation with some species. Infestation will vary from place to place, depending on the type of pasture, but the random sampling over the entire area will tend to offset the variation produced by this.

The parasites found most widely distributed over the whole area were *Haemonchus*, *Ostertagia*, *Trichostrongylus*, *Strongyloides*, *Nematodirus* and *Cooperia*.

VI. DISTRIBUTION OF PARASITES WITHIN THE HOST

It has long been known that different species of animal parasites inhabit a variety of situations within their hosts. The parasites of lambs are no exception so that some consideration has been given to the different habitats which some of these occupy.

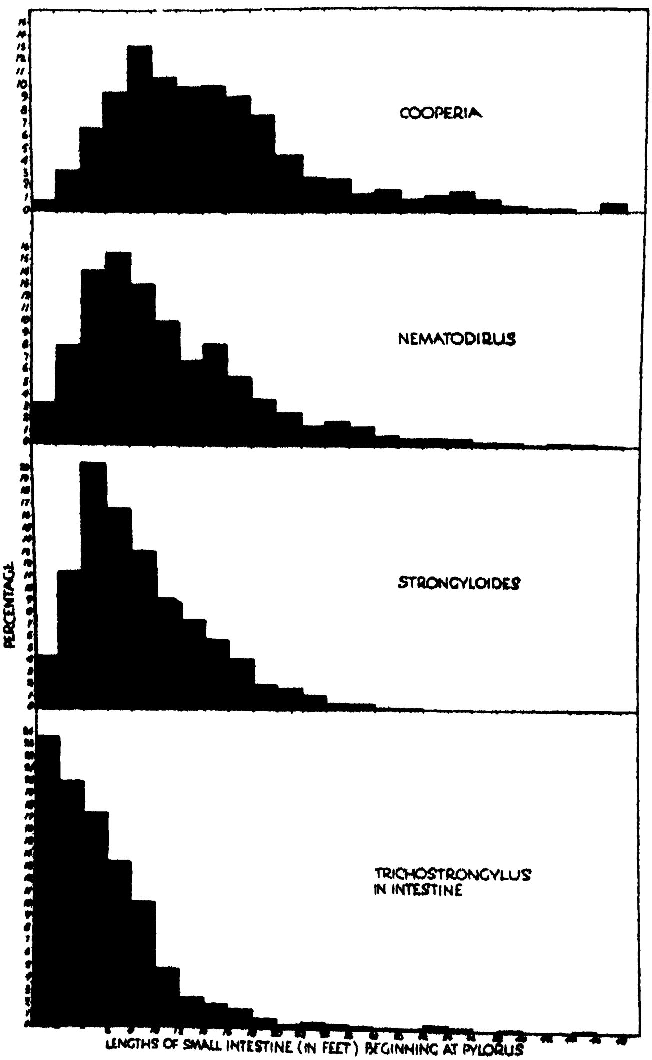


Fig. 19. Comparative numbers of parasites in two-foot sections of the small intestine.

DISTRIBUTION OF TRICHOSTRONGYLUS, STRONGYLOIDES, NEMATODIRUS, AND COOPERIA

The number of worms in each two-foot length of the first fifty feet of the small intestine of twenty-six lambs was determined by tying it off and counting the worms in each of the lengths separately. As it was desirable that the counts have significance, the number of specimens of each genus were not used unless there were at least one hundred present in the animal. Nine of the animals fulfilled these conditions for *Trichostrongylus*; eleven for *Strongyloides*; nineteen for *Nematodirus*; and thirteen for *Cooperia*.

The numbers of each genus were treated as follows: From the total number of worms in the animal the percentage in each section was calculated (table A, appendix). This was done in order to give equal weight to the results whether there were only one hundred specimens present or many times this number. The average percentage in each section was then calculated and from this data figure 19 was constructed.

By reference to figure 19 it will be seen that *Trichostrongylus* reached its peak in the first two feet of intestine; *Strongyloides* in four to six feet; *Nematodirus* in four to eight feet; *Cooperia* in eight to twelve feet. It is to be noticed, of course, that the distribution of all of these genera overlaps to a considerable extent but the fact that the maximum number of one genus occurred in a different section from that of the others is probably of some significance. Moreover, those genera found more distally had a more extensive distribution than those situated nearer the pylorus. That is to say, a larger percentage of *Trichostrongylus* and *Strongyloides* specimens were concentrated in regions of maximum numbers than was found to be the case with *Nematodirus* and *Cooperia*.

DISTRIBUTION OF OTHER PARASITES

Haemonchus contortus, *Ostertagia circumcincta*, and *Trichostrongylus* are found in the fourth stomach. Species of the latter also inhabit the proximal part of the intestine, but *T. extenuatus* occurs more frequently in the stomach. Specimens of the two former species were sometimes found in the intestine. They were never found here in large numbers and may have been on their way to being expelled from the host.

The location of these worms leads to speculation as to how they live in such an acid environment. The cuticle which they possess is no doubt of value in preventing peptic digestion. This is indicated by the fact that it is difficult to get fixing agents and staining media to penetrate it. Experiments by Stewart (1933) suggest the worms secrete some substance which tends to neutralize the peptic ferments. The tendency of the

worms to attach themselves to the mucosa no doubt prevents them from being swept on into the intestine along with the host's food. They must also be adapted to the type of food which they can obtain in the stomach and it may be that they produce substances which prevent peptic digestion but that these are useless against the tryptic enzymes. More conclusive answers to these and other problems relating to the physiology of helminths will be more easily solved if someone succeeds in cultivating the worms *in vitro*.

The tapeworm (*Moniezia*) when mature, must, of necessity, because of its length (20 ft.-30 ft.), be adapted to a considerable range of conditions. The distribution of the worm in the intestine is extensive, not merely because of its size but from point of number of individuals as well. The individual specimens, as determined by the number of scolices, were taken from a wide range of the intestine, beginning 20 feet from the pylorus and extending back to 80 feet or more. The largest number were usually found at least 40 feet or more posterior to the pylorus. Thus, in general, they were located posterior to most of the nematodes. This position is to be expected since possessing no digestive system they must obtain their nourishment by absorption over their body surface. It is not surprising, therefore, to find this parasite where food is present in a state in which it can be absorbed. Further, the tapeworm does not possess as thick a cuticle as some of the nematodes and so may be less able to withstand the action of the digestive juices.

The hookworm (*Bunostomum trigonocephalum*) was seldom taken in large numbers. The largest number was usually found 20-30 feet posterior to the pylorus, although specimens were not always confined to these limits. Their situation in this position raises the question as to what extent their nourishment consists of the host's food which has been broken down by enzymes and to what extent of the host's tissues. If their nutrition is partly dependent on the absorption of already digested or partly digested food material either orally or over the entire body surface it would help to explain their location. Davey (1937) shows a photograph of a hookworm which was attached to a specimen of *Moniezia* in the same host. Does this suggest that the hookworm may not necessarily feed on the host's tissues? A small petechial spot is produced, however, at the point where a worm is attached to the mucosa.

Chabertia ovina lives in the large intestine just posterior to the attachment of the caecum. This situation is probably the most favourable on account of its food supply. Wetzel (1931) has shown that the worms feed on the mucosa and as this is quite thick in the upper part of the colon, this location should be one of the most suitable for the species.

The larvae of *Oesophagostomum columbianum* were found invading the

intestinal wall anywhere from the duodenum to the colon. In some cases the caecum was almost covered by nodules which had been formed about the invading larvae.

DISCUSSION

It is seen from the above that each of the worms is adapted to different conditions such as availability of food, acidity, digestive ferments, peristalsis, and the mechanical passage of food. The processes by which different species have become adapted are no doubt similar to those which have led to the adaptation of all other animals to different habitats.

The nature of the food of some of the parasites may determine to some extent their situation in the host. For example, the tapeworm *Moniezia* is found where food is available in a state in which it can be absorbed. *Chabertia* inhabits the large gut and feeds on the mucosa (Wetzel, 1931), which is comparatively thick in this region. Some parasites as *Haemonchus* and *Bunostomum* are known to take blood from the host. A spectral analysis of the body fluid of *Nematodirus* was made during the present study and it showed the absorption bands for oxyhaemoglobin, which indicates that this parasite also obtains blood.

Differences in the acidity of the environment will not alone account for the distribution found. Determinations of the pH of the abomasal and intestinal contents were made on three different animals by an electrometric method. The fourth stomach had an average pH of 5.5, the first two feet of intestine 6.2, the next two feet 6.4, and for the next twenty feet it was anywhere from 6.6 to 6.7. Thus while the difference in acidity between the first few feet of the intestine and the more posterior portion might be sufficient to account for the situation of *Trichostrongylus* and *Strongyloides*, it would not explain that for *Nematodirus*, *Cooperia*, *Moniezia*, and *Bunostomum*. The range in conditions which many parasites will tolerate has no doubt definite limits, and the extent of these will depend on the adaptation of the parasite to its environment. The limited conditions which parasites will tolerate is indicated by the difficulties which have attended attempts to keep any of them *in vitro*.

It is suggested that a consideration of the distribution and character of some of these worms gives some indication of the comparative length of time during which they have been adapted to the parasitic mode of life. If it is assumed, as is generally believed, that the parasitic habit arose by the chance ingestion of free-living larvae, then it is reasonable to suppose that only those worms which were able to live in their new environment would produce progeny. And only those progeny which inherited the qualities which allowed their parents to survive in the environment would

live. Thus in time a race of parasites would be obtained which was adapted to live only in their new situation.

Attention will be directed especially towards a consideration of the distribution of *Trichostrongylus*, *Strongyloides*, *Nematodirus*, and *Cooperia*, the maximum numbers of which were present in this order, beginning at the pylorus and proceeding posteriorly. In addition, the last two genera had a more extensive range in distribution in the intestine than the two former. It seems that this may indicate that *Nematodirus* and *Cooperia* have been leading parasitic lives for a longer period than the other two and have become adapted to a wider range of environmental conditions. It must be remembered that *Trichostrongylus* also occurs in the abomasum and it may well be that this was the original host environment in which it lived and it is gradually becoming established in the intestine.

One might inquire as to what other evidence there is that *Trichostrongylus* and *Strongyloides* have adopted the parasitic habit more recently than *Nematodirus* and *Cooperia*. Certain morphological features suggest the correctness of this view. The bulbous expansion of the anterior ends of *Nematodirus* and *Cooperia* will assist them in clinging to the mucous membrane. This feature appears to be an adaptation to a parasitic mode of life and is lacking in the other genera. It is a well recognized fact that those worms which possess the largest number of eggs in the uterus are the more highly specialized parasites. Counts of the number of eggs in the uterus which had formed into an oval shape were made. These results are indicated in table 3. If the eggs of some of the worms had recently been shed from the vagina it would account for the variation in the counts which was obtained. It will be observed from the table that there were on the average thirty-three and twenty-one eggs in the uterus of *Nematodirus* and *Cooperia* respectively, and fourteen and thirteen in *Trichostrongylus* and *Strongyloides*. This feature would tend, therefore, to add further weight to the theory, especially if it is assumed that the mortality of the eggs of *Nematodirus* and *Cooperia* is no greater than that for *Trichostrongylus* and *Strongyloides*.

The life-histories of *Nematodirus* and *Strongyloides* lend support to the view that the former has been adapted to the parasitic mode of life longer than the latter. The life-histories of all four are similar in that the eggs hatch outside the host and the larvae lead a free-living existence for a time. The eggs of *Nematodirus* do not hatch immediately they have embryonated, but not until after the second ecdysis of the larvae. At the other end is *Strongyloides* in which there may be a free-living generation of males and females interposed between the parasitic stage in the sheep and the infective larval stage.

And finally there is some evidence, which will be presented in the

following section on seasonal variation in numbers, that a resistance is established against *Nematodirus* and *Cooperia* but is lacking, or develops more slowly against the other two genera.

TABLE 3

NUMBER OF FORMED EGGS IN UTERUS OF DIFFERENT WORMS

Nematodirus spathiger	*Cooperia curticei*	*Trichostrongylus vitrinus*	*Strongyloides papillosus*
28	28	20	17
34	12	13	12
22	12	12	22
32	27	16	18
37	28	10	11
33	27	12	16
33	22	11	10
40	17	15	14
33	20	11	12
39	21	13	18
38	17	11	12
37	20	12	13
24	16	16	15
24	25	14	14
26	24	12	15
32		15	12
29		14	11
33		8	15
40		19	10
20		16	11
47		13	8
32		19	10
37		11	11
36		15	12
40		15	11
—	—	—	—
Aver...33	21	14	13

VII. SEASONAL VARIATION IN NUMBERS

This part of the study has been carried out to determine whether the parasites of lambs are more abundant during one time of the year than another, and also to discover whether the different genera showed a seasonal variation in numbers. This is important to know when we consider geographical distribution. If their numbers vary at different times of the year it is obvious that the sheep population should be sampled over a period, in order to get an accurate picture of the distribution and degree of infestation throughout the province.

AGE OF ANIMALS EXAMINED

The lambs in southern Ontario are born, for the most part, in March, April and May. This means that those shipped to the abattoir during the summer were younger than those received later and those animals examined in March, April and May would be approximately one year old. Although the exact age of the animals was not definitely known they were all, except a few yearlings examined in the spring, less than one year old. Age is important as some workers hold that age resistance has an important bearing on the number of parasites which may be found in an animal. The bearing of this problem on the results of the present study is considered in the discussion at the end of this section.

TOTAL NUMBER OF PARASITES OBTAINED

There is a slight upward trend in the total number of parasites recovered from various lambs proceeding from spring and early summer to autumn (figure 20). It would be expected that the animals examined during the winter would harbour many more parasites than those autopsied in the early summer, if infection consisted of such a simple process as the ingestion of infective larvae. But this does not happen in the case of all genera as is shown in table 4. And it is seen there is no well-marked trend when the average number of all parasites per animal per month are considered (table 5). It is necessary to consider the variation in numbers of the different kinds of parasites at different seasons to account for the rise and fall of total number of parasites throughout the year.

AVERAGE NUMBER OF GENERA PER ANIMAL PER MONTH

The average number of genera per animal per month (figure 21) varied from a low of seven in June to a high of ten in September, the mean of these averages being eight. It is significant that all fifteen genera were not found in any one lamb, and there was only a single animal with as many as twelve genera. This is obviously of advantage to the parasite as well as the host, for the fewer species present the less chance there is of affecting the host adversely and therefore the survival of the worms.

SEASONAL TRENDS SHOWN BY DIFFERENT GENERA

The six more common genera, namely, *Haemonchus*, *Ostertagia*, *Trichostrongylus*, *Strongyloides*, *Nematodirus* and *Cooperia*, were not all present in maximum numbers at the same period although this is not noticeable when they are considered collectively. The genera, such as *Bunostomum* and *Chabertia*, which were usually only present in small numbers, gave no well-marked indication of seasonal variation.

TABLE 4

TOTALS OF VARIOUS GENERA PER MONTH

Month	No. of Animals	*Haemonchus*	*Ostertagia*	*Trichostrongylus* in Abomasum	*Trichostrongylus* in Intestine	*Strongyloides*	*Nematodirus*	*Cooperia*	*Bunostomum*	*Moniezia*	*Oesophagostomum*	*Trichuris*	*Chabertia*
June	8	400	4,852	3,500	2,336	473	3,074	1,427	2	24	1	544	4
July	9	4,074	7,891	140	1,028	1,865	5,844	851	.	65	..	281	5
September	9	14,127	7,005	1,960	5,086	2,958	14,134	8,773	8	269	10	209	41
October	10	2,852	2,127	4,600	5,851	2,225	4,016	4,389	60	10	22	100	81
November	8	700	2,289	22,220	10,150	3,030	2,622	4,750	24	201	5	123	64
December	8	60	140	17,780	8,148	2,334	1,061	3,434	27	938	9	58	131
January	9	200	300	14,400	13,974	2,250	4,134	1,102	87	2	59	44	133
February	10	92	4,613	38,120	24,307	3,519	13,697	13,958	86	..	65	38	682
March	12	440	4,300	18,020	10,598	3,122	2,257	8,200	214	..	62	39	207
April	9	1,894	5,492	18,900	3,059	2,317	1,844	2,007	25	1	4	48	371
May	12	2,422	8,771	22,416	4,691	1,472	944	4,780	166	4	47	19	724
June	13	180	14,669	1,800	381	2,622	18,602	8,379	28	589	4	206	34
July	12	2,840	8,355	320	206	897	3,764	1,141	33	177	..	131	20

TABLE 5

MAXIMUM, MINIMUM AND AVERAGE NUMBER OF WORMS FOUND PER ANIMAL IN DIFFERENT MONTHS

Date	No. of Animals Examined	Max.	Min.	Aver.	Total No. of Parasites
April, 1935	6	2,892	50	983	5,901
May, 1935	9	8,850	611	3,518	31,662
June, 1935	8	5,869	340	2,211	17,688
July and Aug. 1, 1935	9	8,796	511	2,856	25,708
Aug. 30 and Sept., 1935	9	22,075	2,208	6,841	61,572
October, 1935	10	5,654	1,152	2,834	28,342
November, 1935	8	14,974	2,450	5,881	47,051
December, 1935	8	11,301	292	4,446	35,572
January, 1936	9	8,965	959	4,277	38,493
February, 1936	10	22,808	1,133	9,993	99,933
March, 1936	12	7,097	1,070	4,130	49,560
April, 1936	9	12,475	428	4,264	38,376
May, 1936	12	14,023	361	4,299	51,311
June, 1936	13	22,026	201	5,069	65,902
July, 1936	12	2,970	647	1,941	20,592

INCIDENCE OF INFECTION

The percentage of lambs examined which were infected with the more common parasites is shown in figure 22. The greatest incidence for *Haemonchus* and *Ostertagia* occurs in late summer and early autumn. Some specimens of *Trichostrongylus* and *Strongyloides* were found in almost 100 per cent of the animals examined at all seasons. This contrasts with the work of Kauzal (1933) in Australia, who found the incidence with *Trichostrongylus* fell from a peak in the summer quarter to a low minimum in the winter. The incidence of infection with the other forms shows no significant trends except in the case of *Oesophagostomum*, *Muellerius* and *Moniezia*. Infection with the two former, as indicated by the presence of either worms or nodules, was higher in the winter than in the summer. The nodules produced by these parasites remain as evidence of infection even though the worm may have been destroyed in the nodule. Consequently, the larger number of the older animals examined during the winter will be infected because they have been exposed to infection for a longer time. The infiltration of eosinophile leucocytes during the nodule formation in the case of *Oesophagostomum columbianum* suggests an attempt on the part of the host to resist the invasion. This seems the opposite to what we might at first expect for we think of a

resistant animal as one which possesses a slight infection or none at all. But in the case of this parasite the most resistant host may be the one which shows the greatest evidence of infection. This is, however, a special case in which the larvae produce calcified lesions which remain permanently on the intestine; whereas in those species which pass their entire lives in the lumen of the intestine, their larvae may be passed out, if the animal is resistant, without leaving any record of their invasion. The number of adult worms found in the lambs was usually quite small (table 4).

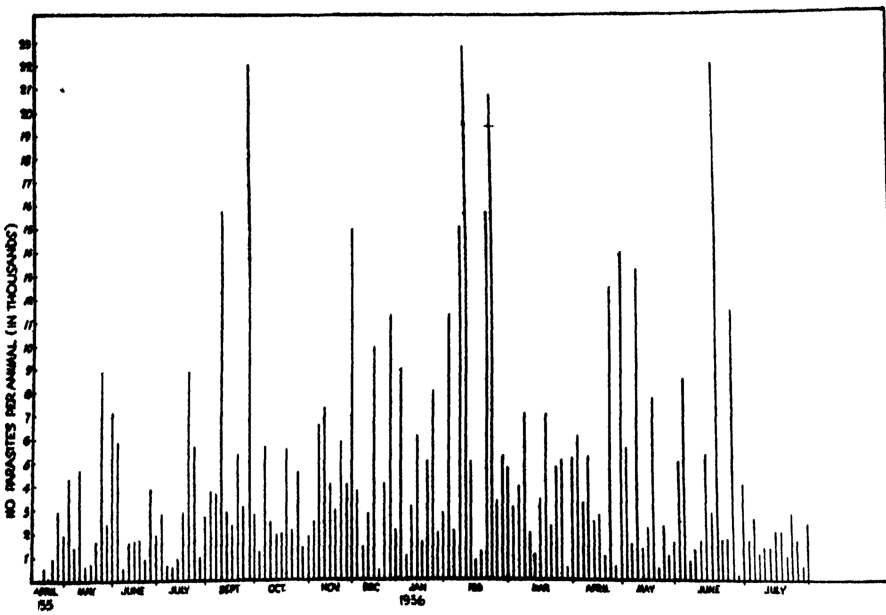


Fig. 20. Number of helminth parasites obtained from different lambs.

Thirty-five per cent of the lambs examined were infected with *Moniesia*. The largest number infected was found in summer and early autumn. This was followed by a gradual decrease until February and March when no infected animals were examined. Two possibilities suggest themselves to account for this. It may be that the host develops some resistance against this parasite. Seddon (1931)[1] produced some experimental evidence, showing that previously infected sheep when exposed to re-infection had developed some immunity against this parasite.

The life-history may be such as to produce these trends. The chances of acquiring infection after mid-November appear to be small, especially if an intermediate host is involved, although it is not yet known how

sheep become infected. Thus if the worms lived only 2-3 months in the host, one would not expect to find many infected animals by February and March. This is in agreement with the finding of Seddon (1931)[2], who gave 65-70 days as the average length of life of *Moniezia* in the host, although he got some which lived as long as 75 days. Recent independent work by Stoll at the Rockefeller Foundation and by Stunkard at New York University gives promise of some positive experimental results on the life-history of this tapeworm in the near future.

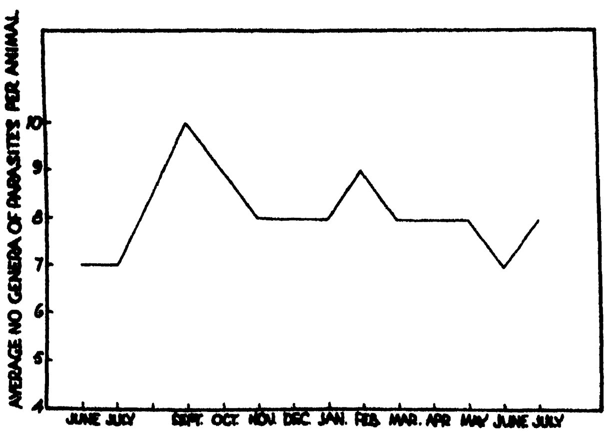


Fig. 21. Average number of genera per animal per month.

DEGREE OF INFESTATION

A consideration of the degree of infestation with some of the more common parasites reveals certain seasonal trends not apparent from the incidence of infection. This is shown in table 4 and figure 23.

Haemonchus contortus has been considered by workers in some countries to be one of the most serious parasites of sheep. Ransom (1916) pointed out that it is the cause of a great deal of damage to the live stock industry, and Monnig (1934) speaks of it as one of their most pathogenic species. Sixty per cent of the animals examined during the present study harboured this worm. The maximum, minimum, and average number of worms found per animal is shown in table 1.

Maximum infestation with this parasite was found in late summer and early autumn (table 4), an average of 1,561 worms being recovered from each animal examined during September. This dropped off to a minimum of eight worms per animal in December and February. There was a slight rise again in early spring. The increase in the degree of infestation in the animals examined in July, 1936, is also to be noted as the new "crop" of lambs was on the market at this time.

Ostertagia circumcincta was recovered from 82 per cent of the animals examined (table 1). The average number of worms per animal (546) was twice as high as that for *Haemonchus*. The average number of specimens of *Ostertagia* per lamb recovered in the various months followed a trend similar to that shown by the monthly incidence of infection. Minimum

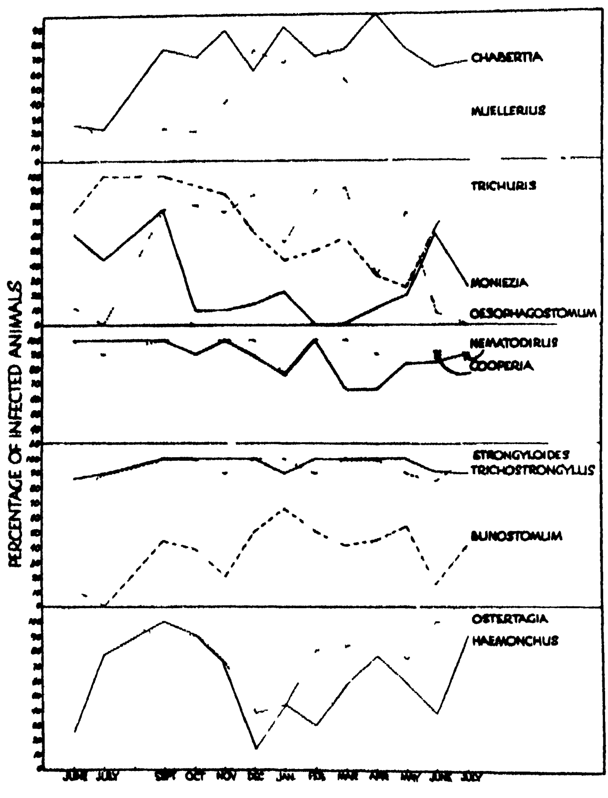


Fig. 22. Percentage of animals infected with various parasites.

infestation was found in December and January (table 4, figure 23). The seasonal fluctuation for this genus was then similar to that of *Haemonchus* except in the latter case the numbers dropped off to a minimum more quickly than with *Ostertagia*. The peak of infestation with *Ostertagia* occurred a little earlier in the summer than did that of *Haemonchus*.

The three species of *Trichostrongylus* were not counted separately, as this could not be done with accuracy at the low magnification used to make the counts. More animals were found infected with these parasites than with any other, ninety-three per cent. showing intestinal infestation

and 82 per cent abomasal. The lower value for the latter may be partly due to counting only a portion of the diluted sample of the abomasal contents. Some worms may also have been overlooked among the debris which was almost invariably present in the abomasum.

The degree of infestation with this genus in different months showed a distinct difference to that of *Haemonchus* and *Ostertagia* (table 4, figure

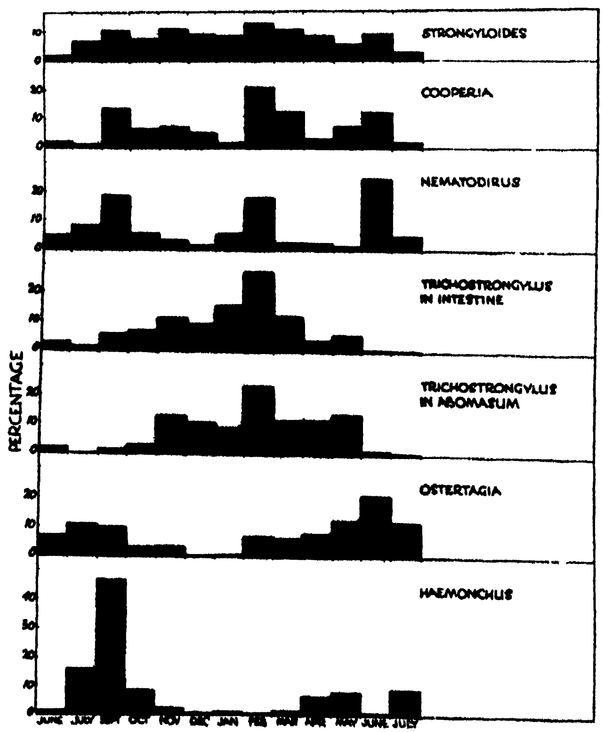


Fig. 23. Percentage of the total infestation with each of the above genera found in the different months.

23). Maximum infestation occurred during the winter months. Smallest numbers were recovered in summer, at which time of year the youngest animals were examined.

Strongyloides papillosus was found in most of the lambs (93%) and the degree of infestation was rather uniform throughout the year. The smallest numbers occurred in early summer (table 4, figure 23).

Maximum infestation with *Nematodirus* and *Cooperia* was found during summer and early autumn with an additional peak in mid-winter.

This was not so marked with *Cooperia* as with *Nematodirus*. Infection with *Nematodirus* can be acquired early in the spring.

The number of immature worms obtained in the different months is indicated in tables 6 and 7. The worms were classed as immature if they were either partly grown adults or only larvae.

TABLE 6

NUMBERS OF NEMATODES IN ABOMASUM EXCLUDING NEMATODIRUS AND COOPERIA

	No. of Animals Examined	Total No. Nematodes	No. of Immatures	Per cent. of total which are Immature
June	8	5,200	140	2
July	9	14,200	3,200	22
September	9	25,250	4,640	18
October	10	9,660	80	0.8
November	8	25,680	640	2
December	8	18,040	60	0.3
January	9	15,800	0	0
February	10	42,800	40	0.1
March	12	24,760	1,840	7
April	9	27,980	1,940	7
May	12	37,676	4,060	11
June	13	19,210	3,420	18
July	12	13,020	1,560	12

TABLE 7

NUMBER OF NEMATODES IN SMALL INTESTINE

	No. of Aninals Examined	Total No. Nematodes	No. of Immatures	Per cent. of total which are Immature
June	6	5,453	1,312	24
July	9	10,075	2,192	22
September	9	35,650	4,380	12
October	10	18,471	1,931	10
November	8	21,069	1,353	6
December	8	16,886	1,218	7
January	9	22,416	909	5
February	10	56,416	716	1
March	12	24,162	81	0.3
April	9	9,773	474	5
May	12	12,445	495	4
June	13	45,312	15,107	34
July	12	7,204	1,147	16

It is apparent from these tables that the lambs acquired little infection during the winter months, although some immature specimens were found even then and it was observed that many of them were *Nematodirus.* Some infection with this worm during the winter might be expected as experiments outlined below show that the eggs of this parasite will withstand $-10°C$. For the most part, however, few immatures are likely to be found during the winter as the temperature at this time of year is sufficiently severe to retard the development of the eggs outside the body of the host and may even destroy those of some species. The number of immatures shown for the abomasum for June, 1935, is too low, for at the beginning of the study some of the partly grown worms were identified and included with the counts of the mature ones.

DISCUSSION

It is seen from the foregoing that *Haemonchus*, *Ostertagia*, *Trichostrongylus*, *Cooperia* and *Strongyloides* were present in the largest percentage of animals and in greatest numbers. *Trichostrongylus* was most abundant in winter. *Strongyloides* was found in more uniform numbers throughout the entire year. The other four genera were most abundant in summer and early autumn, but the latter two showed a peak in February also.

The degree of infestation will depend on the presence or absence of infective material. This is, in turn, related to temperature and humidity. Infection may be influenced by the susceptibility, tolerance and resistance of the host and the life-history of the parasite. Experiments described later indicate the eggs of some species may be killed by our winter temperature while others probably survive. This may influence the rate at which infection may be acquired with different species in the spring. This differential survival will not, however, account for some of the differences found. These appear to depend on the life cycle of the parasite as well as a host resistance which possibly may develop against some species but not others.

The probable effect of the life cycle of *Moniezia* on infestation with it was discussed above. The host resistance which is important in the case of *Oesophagostomum columbianum* infection has also been discussed. It might be expected that the healthiest lambs would be most resistant to the larvae of this worm and if they had been exposed to infection would therefore contain large numbers of nodules. If this were true, the Grade A lambs might be expected to show the most nodules on the gut. One hundred and fifty lambs were examined to test this hypothesis, but the results gave no evidence that such was the case. Other factors must be responsible for the type of resistance shown by nodule formation.

It is suggested that the low infestation with *Haemonchus contortus* in the autumn and winter as compared to the late summer may be the result of a resistance which the host develops against this parasite. This view is supported by the results of Stoll's (1929) experimental studies in this species. He placed a susceptible animal on experimental plots which contained infective *Haemonchus* larvae. This resulted in a definite accumulation of the parasites in the host for a time, as revealed by counts made on the number of eggs in the faeces. This was followed by the host exhibiting a self-cure, resulting in a decrease in the infestation and development of resistance to further infection. Further dosing with infective larvae did not succeed in establishing them and causing a heavier infestation, but instead it remained quite low for the remainder of the experiment. The increase in the degree of infestation in April and May is believed to indicate that some of the animals lost their resistance after a time and began to acquire fresh infection. The increase in numbers observed for these two months, at which time the oldest animals were examined, indicates that the factor of age resistance was not responsible for the decrease in numbers which was observed in previous months.

The results for *Ostertagia*, *Nematodirus* and *Cooperia*, although not showing such definite trends as *Haemonchus*, were similar, with the possible exception of *Cooperia*. *Nematodirus* and *Cooperia* showed an additional peak of abundance in mid-winter not shown by the others. This rise, which occurs in winter when the climate is such as to prevent fresh infection, can be explained by supposing that the resistance is only temporary and that if this disappears before the onset of winter the lambs will acquire some fresh infestation. Perhaps it may be that the most heavily parasitized animals did not reach the market until February, having been withheld from sale until this time because of stunted growth due to parasites.

Tetley (1935) found high numbers of *Nematodirus* in New Zealand from November to April, and low numbers the rest of the year. He got a decline in numbers in animals over six months old and scarcely any in individuals over nine months old. He thought an acquired immunity of long standing was developed against this parasite. If the present results are to be taken as indicating a resistance it does not appear so permanent. He found the largest numbers in healthy lambs. This seems surprising, for although little information is available on the pathogenicity of *Nematodirus*, the writer found, by spectral analysis, that the body fluid contained oxyhaemoglobin, suggesting the parasites are blood suckers.

The present writer agrees with Tetley's (1935) conclusion that there was no such thing as age resistance for this parasite. This is shown by the fact that the lambs examined in February were older than those exam-

ined in previous months yet the February animals were the more heavily infested. Several writers have held that age resistance may be an important factor in the immunity of an animal to parasitic infection. Notably among these are Fulleborn *et al* (1928), who was quoted by Sandground (1929), "Eine allen experimentierenden Helminthologen bekannten Erscheinung ist es, dass sich ältere Versuchtiere auch per os schwerer infizieren lassen als jüngere Exemplare. . . ." Sandground's view (1929) seemed to be that in age resistance it is a case of the host developing certain of its specific characters which are antagonistic to the parasite, rather than that the older host develops against the parasite specific antigenic substances which are not produced by the younger animal. This would seem like a reasonable view.

A distinct difference in the seasonal distribution of *Trichostrongylus* was found as compared to those discussed above, for with it maximum infestation was found during the winter. In this case the trend cannot be due to a resistance, for if such were true one would expect to get a drop in the degree of infestation toward winter. If the host has no resistance against a parasite and infective larvae are available for ingestion, then the older animals which were examined in late autumn and winter would be expected to be harbouring larger numbers of parasites, unless the rate of loss of parasites from the animal was about equal to the rate of ingestion.

The smaller infestation with *Trichostrongylus*, in June and July, as compared to *Haemonchus* may be due to a lower biotic potential of the former. The average number of formed eggs (based on counts in 25 worms) in the gravid uterus of female *Trichostrongylus vitrinus* was 14 as compared with the hundreds found in a similar specimen of *Haemonchus*. The larger number obtained in June, 1935, as compared to the same month in 1936 was due to the presence of a year old animal among those examined in June, 1935. The biotic potential will also depend, of course, on other factors such as rate of egg production, rate of hatching of eggs, and time taken to reach the infective larval stage.

The infestation with *Trichostrongylus* followed a course in the abomasum similar to that in the intestine, although there was a decline in the number found in the intestine in April and May which was not found for those in the abomasum. The question arises as to whether this may be an indication of a developing host resistance.

There was no indication of the development of a host resistance against *Strongyloides papillosus*, neither was there any marked accumulation of this parasite at any season. This suggests that the rate of ingestion must have been only slightly greater than the rate of loss of the parasites from the host.

Taylor (1934)[2] made observations on the resistance of lambs to para-

sitic gastritis caused by a mixed infection with trichostrongylid nematodes. He concluded that lambs could acquire an "immunity" which would protect them against an infected pasture which was sufficiently contaminated to produce death in unprotected animals, although resistant animals might harbour more parasites than were carried at the time of death by non-resistant animals. The "immunity" was acquired slowly. He found the "immunity" was more effective against *Haemonchus contortus* and *Nematodirus filicollis* than against *Ostertagia*, *Trichostrongylus* and *Cooperia*. The present study gives support to his view that an "immunity" develops against these parasites but would include *Ostertagia* and *Cooperia* also. Taylor pointed out that the "immunity" tended to inhibit egg production and that adversely affected the development of the young worms.

An eosinophilia in a parasitized animal has been regarded by some workers as an indication of its resistance against the parasite. The work of Hadwen (1925) on ascariasis in horses showed that resistance to infection with this parasite was related to the production of an eosinophilia. Since then Maass (1933) showed that a similar phenomenon was produced in pigs infected with *Trichinella spiralis*. Backman and Molina (1933) working on the same parasite concluded that the resistance was due to retention of anti-bodies and local mobilization of leucocytes and cells of the reticulo-endothelial system in the intestinal wall of the host.

The mixed infection found in the animals examined during the present study made it of little use to attempt to find any eosinophilia in the circulating blood. An eosinophilia, however, was found surrounding some of the nodules caused by *Oesophagostomum columbianum*. The resistance which the host develops against this parasite is apparently a local phenomenon developing against the larvae following their invasion into the mucosa.

Haemonchus and *Bunostomum* are known to obtain blood from the host. The finding of oxyhaemoglobin in *Nematodirus* suggests it may too. The question arose whether blood cells could be demonstrated in the intestinal content of these worms. Further, if the host's resistance is related to the the presence of an eosinophilia, might it be possible to find these leucocytes in the intestine of the parasite, and especially if the eosinophilia, were a local phenomenon? All attempts to demonsrate this by teased preparations, pressed preparations, and sections have so far been negative.

Stumberg (1933) demonstrated, by means of an allergic test, the proteins of *Haemonchus contortus* in the sera of sheep and goats infected with this parasite. The local nature of resistance against parasitic infection is suggested by the work of Chandler (1935) on *Nippostrongylus muris*.

If the resistance of lambs to some of their parasites is of a local character then only the cells in the immediate vicinity of the parasites will be concerned with it. The resistance would thus be lost as these cells are replaced by new ones. This will fit in then with the temporary nature of the resistance for some of the species, which has been postulated from observations on their seasonal variation in numbers. The fact that it appears more temporary for *Nematodirus* than for *Haemonchus* and *Ostertagia* may mean a more rapid replacement of cells in that part of the intestine in which *Nematodirus* lives as compared to the stomach. Or it may mean the original resistance against the latter was weaker and involved fewer cells than in the case of the other two.

Conditions affecting the larvae in their external environment as well as within the host will affect the degree of infestation with different species. La Page (1935) expresses such a view when he says: "It is conceivable that much of the so-called resistance of animals to experimental and even to natural infection with infective larvae, is little more than the expression of differences in the vitality and ability of these larvae to perform successfully the second, third and fourth ecdyses upon which the attainment of the adult stage depends." This would help to explain the inequalities which have been observed in the numbers of the sexes of the different species which were obtained. It will be seen below, when the sex ratios are considered, that the inequal numbers were not due to one sex being shorter lived in the host than the other. It seemed more likely that the larvae of one sex were more easily killed either before or after ingestion by the host.

Diet has been considered by some workers to be an important factor in determining the susceptibility of animals to infection. Ross and Gordon (1933) studied the effects of the nutrition of sheep on their resistance to *Haemonchus* infection. They found if the diet was so deficient in proteins and minerals that a marked loss of weight and condition resulted then the animals were more susceptible to infection. Kauzal (1934) concluded that susceptibility of sheep to *Dictyocaulus filaria* infection was not influenced by a deficient diet nor by concurrent infection with *Haemonchus contortus*. Fraser and Robertson (1933) concluded that well-fed lambs were more resistant to infection with *Haemonchus contortus* than poorly fed ones. Diet is not the cause of the difference in numbers obtained in the present study, for it will be noticed there was a marked decrease in the degree of infestation with *Haemonchus contortus* in October and there was decrease in infestation with *Nematodirus* between February and March, yet there is no alteration in diet to account for these differences. It is to be expected that animals which are weak or run down because of a deficient diet may be more heavily parasitized than those on a well balanced

TABLE 8

SEX RATIOS

	Haemonchus		*Ostertagia*		*Trichostrongylus* in abomasum		*Trichostrongylus* in intestine		*Nematodirus*		*Cooperia*	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
June	80	280	2,240	2,240	160	60	24	24	1,172	1,390	507	681
July & Aug. 1	1,580	1,500	3,400	4,240	380	420	473	517	2,522	2,694	235	399
Aug. 30 & Sept.	5,320	5,690	2,600	4,060	660	1,300	2,271	2,814	7,199	6,875	4,261	4,492
October	1,260	1,580	1,080	1,020	2,180	2,480	2,556	3,295	2,577	1,319	1,938	2,531
November	220	500	860	1,540	11,220	14,640	4,781	5,399	1,538	1,065	6,533	7,299
December	40	20	80	60	7,660	10,120	3,704	4,454	698	363	1,561	1,853
January	40	160	60	140	6,360	8,040	6,259	7,715	2,262	1,852	381	721
February	....	80	2,040	2,540	18,000	20,360	10,677	13,755	7,589	6,693	6,042	7,839
March	260	200	2,240	3,280	7,760	10,260	4,359	6,149	1,343	854	3,541	4,439
April	740	1,140	2,300	3,160	7,620	11,280	1,242	1,817	1,036	808	907	1,090
May	1,120	1,220	4,000	4,760	9,331	13.085	2,124	4,771	524	399	1,973	2,787
June	60	100	6,380	8,040	620	1,180	190	191	9,808	8,681	3,721	4,708
July	1,340	1,500	3,900	4,440	80	240	93	113	1,958	1,806	412	729

ration. The mixed sampling of the animals from different localities militates against the possibility that this was responsible for the trends observed.

TABLE 9

SEX RATIOS OF VARIOUS PARASITES EXPRESSED AS $\frac{\text{Females}}{\text{Males}}$

The ratio was not included unless at least one thousand worms of any one genus were recovered during the month

Month	*Haemonchus*	*Ostertagia*	*Trichostrongylus* in abomasum	*Trichostrongylus* in intestine	*Nematodirus*	*Cooperia*
June	....	1	....	....	1.2	1.3
July & Aug. 1.	0.95	1.2	....	1.1	1.1	....
Aug.30 & Sept.	1.1	1.6	2.0	1.2	0.96	1.1
October	1.3	0.9	1.1	1.3	0.51	1.3
November	....	1.8	1.3	1.1	0.7	1.1
December	....	...	1.3	1.2	0.52	1.2
January	....	...	1.3	1.2	0.8	1.9
February	....	1 2	1.1	1.3	0.88	1.3
March	....	1.5	1.3	1.4	0.64	1.3
April	1.5	1.4	1.5	1.5	0.78	1.2
May	1.1	1.2	1.4	2.2	....	1.4
June	....	1.3	1.9	....	0.89	1.3
July	1.1	1.1	....	....	0.92	1.8
Average	1.2	1.3	1.4	1.4	0.8	1.4

VIII. GEOGRAPHICAL DISTRIBUTION OF PARASITES IN ONTARIO

Efforts to trace the geographical distribution of the parasites were confined to that portion of southern Ontario extending from the south-western boundary of the province to Picton on the east and Wiarton on the north.

Practically all the species found in the present study appear to be uniformly distributed throughout that portion of Ontario from which lambs were received. That this general distribution probably does not hold for wider areas is indicated by the fact that *Oesophagostomum columbianum*, which is common in that part of Ontario surveyed, appears to be absent from the prairie provinces. Ross and Gordon (1936) state that *O. columbianum* is rare in Canada and that *O. venulosum* is more common.

The latter species was never taken during the present study, whereas the former, or the lesions caused by it, were found in over 40 per cent of the animals.

Figures 24-29 illustrate the places at which the different species of parasites were found, with the exception of *Dictyocaulus*, *Capillaria* and

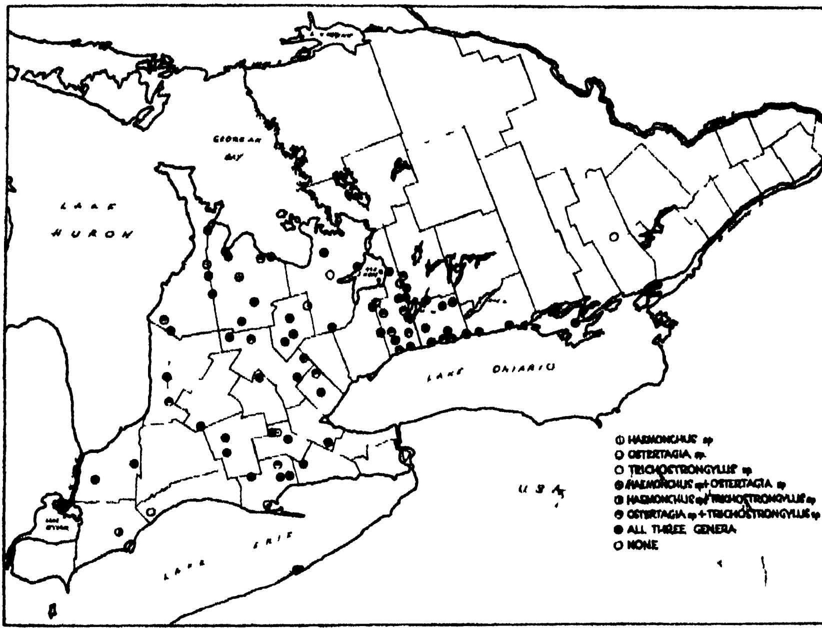


Fig. 24. Geographical distribution of *Haemonchus, Ostertagia,* and *Trichostrongylus.*

Ascaris. *Dictyocaulus* was found in a single animal from Clinton. *Capillaria* was found in animals from Simcoe, Rodney and Ripley. Immature specimens of *Ascaris* were found in an animal from Shelburne.

It will be seen from the figures that all the parasites found most commonly in the lambs examined during the present study were generally distributed in the southern part of the province which has been included in this study. Although all species were not found in lambs received from all localities, the random distribution throughout the entire district suggests these parasites are present in all parts of it. Failure to find some is, no doubt, related to lighter infestation with these species. Thus potentially infective material was present over the entire area and under more suitable conditions heavier infestations might be expected. The seasonal differences in the percentage of animals infected with the various species shows the necessity, in studying geographical distribution, of

examining animals over a period rather than at only one time of year. That is even more important in a study of the degree of infestation with different species in the various localities for the incidence of infection may be high but the degree of infestation low. In this study lambs were received at each season from widely separated points in the area.

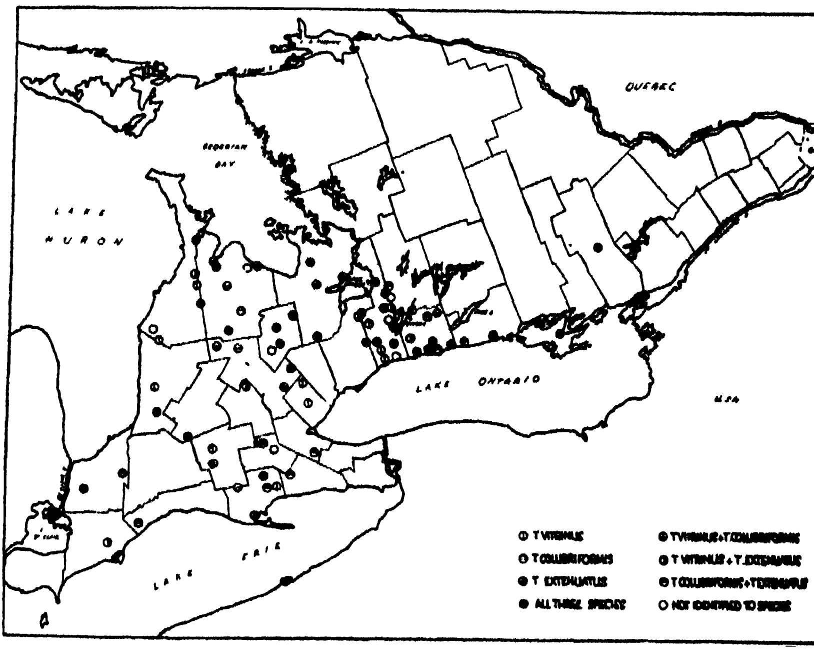


Fig. 25. Geographical distribution of three species of *Trichostrongylus*.

IX. SEX RATIOS OF PARASITES

The ratio of females to male worms is indicated in tables 8 and 9. With the exception of *Nematodirus*, the females were more numerous than the males. The averages obtained for the whole year gave ratios of female to males of 1.2 for *Haemonchus*, 1.3 for *Ostertagia*, 1.4 for *Trichostrongylus*, 1.4 for *Cooperia*, and 0.8 for *Nematodirus*. In spite of experimental errors the differences are thought to be significant. The error in counting the worms in only a portion of a diluted sample is quite large especially if there are only a few worms present. Consequently the numbers obtained for any genus were not included in calculating the sex ratio unless at least one thousand specimens of the genus had been taken during the month. In the case of *Trichostrongylus*, the males are small and some may be overlooked among the debris so that the error for this genus would be

weighted in favour of the females. This probable error does not hold for the other genera. The error in counting the numbers of *Nematodirus* may favour the males when a fraction of the sample only was counted, for the males are smaller and more likely to be pipetted up than the females.

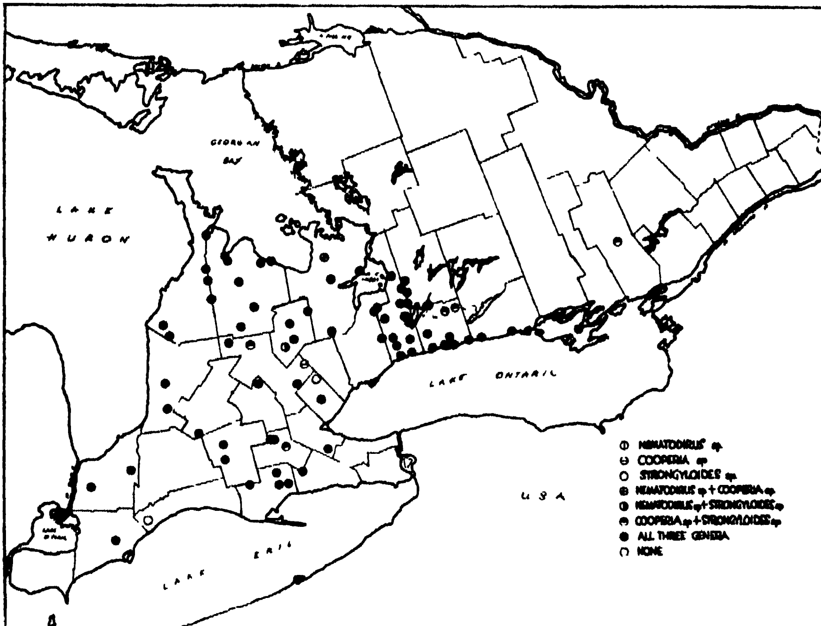


Fig. 26. Geographical distribution of *Nematodirus, Cooperia,* and *Strongyloides.*

The preponderance of females over males in four of the genera is not due to the males being shorter-lived than the females. If this were the explanation the ratio should increase towards the spring as the lambs would have lost a number of their male parasites and there was little infection acquired during the winter (tables 6 and 7). Table 9 shows, however, that the ratio did not increase at this season. This suggests that this difference is characteristic for these parasites and is due either to a fundamental difference in the sex ratios or to a differential mortality of the larvae.

The unequal numbers of the sexes may produce an error in the faecal egg count as a quantitative method for diagnosing parasitic infection. If the males are present in smaller numbers than the females the latter may not all be inseminated. Then the quantitative diagnosis of infection

by counting the number of the eggs in the faeces would give too low a value, assuming that insemination is requisite for the production of eggs. May the diminution in egg production noted by several authors in cases where a large number of worms were present be due then to a lack of insemination of all the females? The unequal numbers of the sexes of the

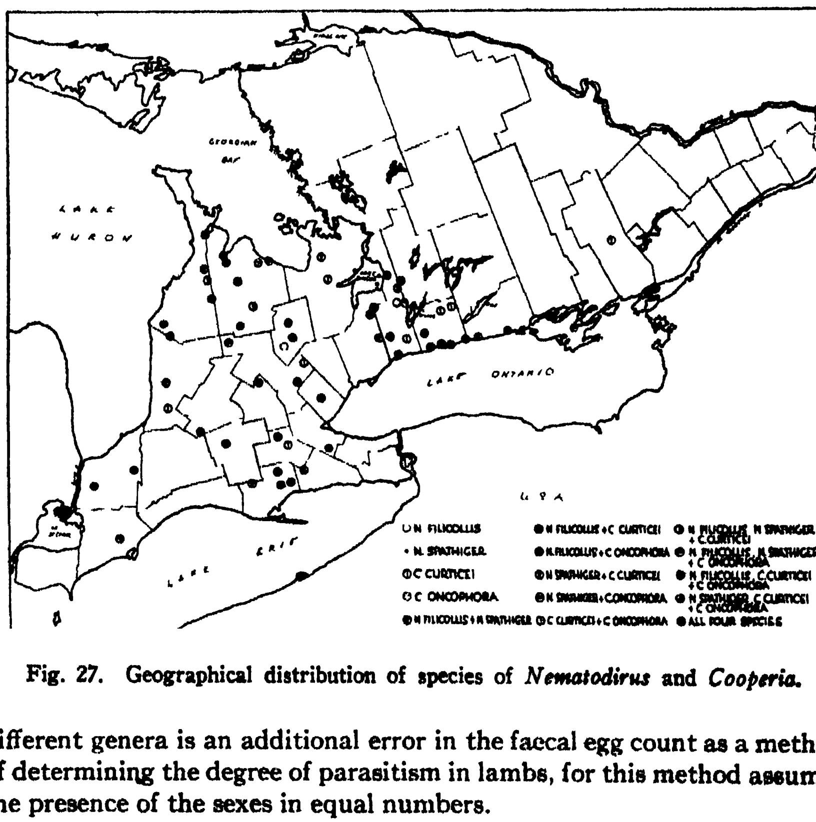


Fig. 27. Geographical distribution of species of *Nematodirus* and *Cooperia.*

different genera is an additional error in the faecal egg count as a method of determining the degree of parasitism in lambs, for this method assumes the presence of the sexes in equal numbers.

X. PATHOGENICITY OF VARIOUS SPECIES

Some species of sheep parasites have been shown to be pathogenic. Serious and even fatal effects have been attributed to *Trichostrongylus* (Ross and Gordon, 1936). The damaging effects of *Haemonchus contortus* are also well known. Martin and Ross (1934), assuming that the phosphorus in the eggs was derived from the blood of the host, determined the amount of blood being consumed by the worms. They concluded that an infestation of four thousand worms, 50 per cent of which were females, would account for a blood loss of 60 cc. daily. Robertson (1933) did not

find clinical symptoms unless there were at least eight thousand *Ostertagia circumcincta* present, but if there were 15,000-20,000 they were liable to cause death. An inflammatory condition of the mucous membrane of the abomasum was noted during the present study if there were more than 4,000 worms present in it. The mixed infections invariably found in

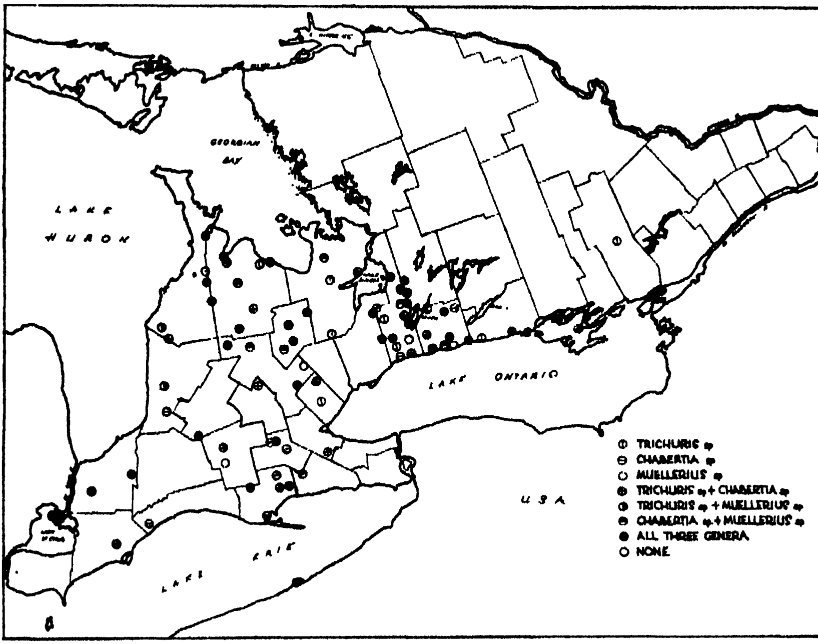


Fig. 28. Geographical distribution of *Trichuris, Chabertia,* and *Muellerius.*

such cases made it impossible to say which of the parasites, *Haemonchus*, *Ostertagia* or *Trichostrongylus* were responsible. Little is known of the pathogenicity of *Nematodirus*, *Cooperia* and *Moniezia*.

Kauzal (1936) gave evidence to show that immature *Chabertia ovina* ingest blood. Daily infestation did not produce symptoms proportional to the rate of infestation. Wetzel has shown that the adults feed on the mucosa.

It was suspected that the pathogenicity of different species might be related to the presence or absence of a toxic factor in the parasites. Experiments were carried out, therefore, to determine whether such a substance might be present. The power to haemolyze red blood cells was taken as the test of toxicity. Saline extracts of the following worms were used: *Haemonchus, Ostertagia* and *Trichostrongylus* (combined), *Nema-*

todirus, *Trichuris*, and *Moniezia*. The worms were dried in a vacuum oven and stored over phosphorus pentoxide. They were then ground in a mortar, following which a 5 per cent saline suspension of each was made. This suspension was added in 0.1, 0.2, 0.3, 0.4, 0.5 and 0.6 cc. quantities to 0.5 cc. of a 1 per cent. suspension of sheep red blood cells, after

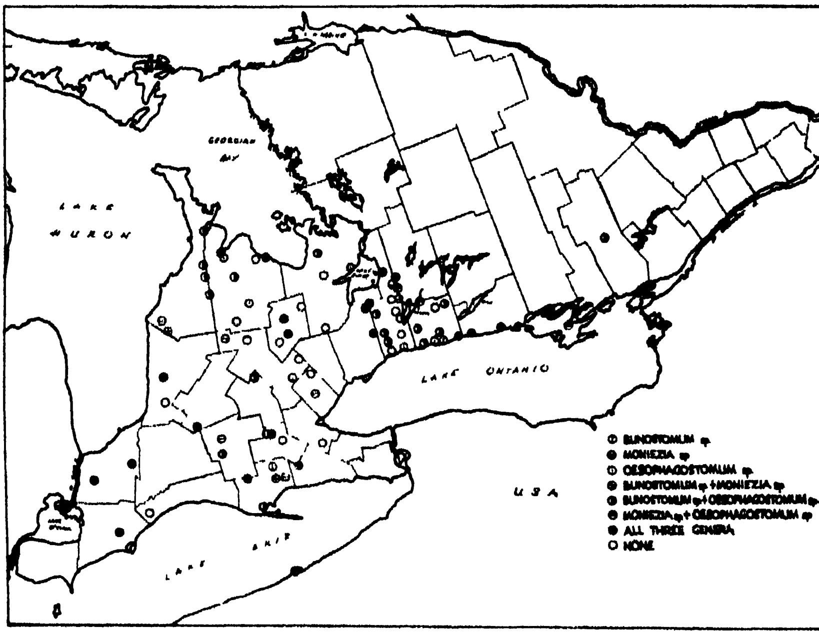


Fig. 29. Geographical distribution of *Bunostomum, Oesophagostomum,* and *Moniezia.*

Schwartz's method (1921). The history of the sheep from which the cells were used was not known. The tubes were shaken and placed at 37°C. for 16 hours. Slight haemolysis occurred in the tube containing 0.6 cc. of the extract of the worms from the abomasum, and in the tubes containing 0.4, 0.5 and 0.6 cc. of *Trichuris* suspension. No haemolysis occurred in any of the other tubes. The results indicate the presence of slight amounts of toxin for *Haemonchus*, *Ostertagia* and *Trichostrongylus* (combined) and for *Trichuris*.

XI. EFFECT OF LOW TEMPERATURE ON THE EGGS OF SOME SPECIES

It was relatively late in the spring before the animals acquired much infection (tables 6 and 7). The question arose as to whether the eggs and larvae of some species were killed at low temperatures such as occur in winter.

An experiment to find the effect of $-10°C.$ on the eggs was carried out. This is 1°C. lower than the mean air temperature recorded at Lindsay. It is realized that the air temperature will differ from the soil temperature. The latter will be variable, depending on the amount of vegetation on the field, amount of snow covering it, and so on.

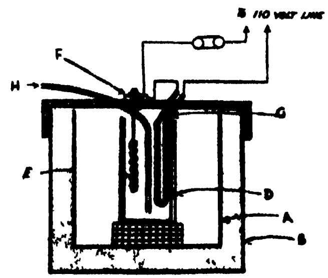


Fig 30. Diagram of apparatus used to maintain nematode eggs at a low temperature.

The eggs were dissected out of the uterus of living worms. A number of eggs not far enough developed to continue segmentation outside the body of the worm was always obtained by this method. For this reason a control was always kept at room temperature, using eggs from the same batch as those being kept at $-10°C.$ The results were not considered valid unless some of the control eggs hatched.

The low temperature was maintained by means of the following apparatus, a diagram of which is shown in figure 30.

It consisted of a five-gallon stone crock *A* set into an insulated box *B*. The crock was partly filled with ethylene glycol. A home-made thermos bottle *D* of one quart size was supported in the ethylene glycol solution. A solution of about 30% alochol was put in the thermos bottle. The bimetallic helix *E* of a De Khotinsky thermo-regulator *F* dipped into the alcohol. A heating unit *G* was also immersed in the alcohol. The heating unit and regulator were connected to a 110-volt power line. Two 200-watt bulbs were placed in parallel in the circuit. "Dry ice" was added periodically to the glycol in *A*. This kept the temperature of the glycol below $-10°C.$ which in turn cooled the alcohol in *D* to this temperature. The thermo-regulator was adjusted so that if the temperature of the alcohol dropped half a degree below $-10°C.$ the circuit was completed and the heater *G* restored the temperature to $-10°C.$ when the circuit was automatically broken again. The alcohol solution was stirred by bubbling in air through a tube *H*. The apparatus maintained a fairly constant temperature if the ice was added regularly and the alcohol was

kept well mixed. There were times, however, when the temperature did get as high as $-7°C$. although it never went lower than $-11°C$. The worm eggs were placed in about 1 cc. of water in test tubes which were stoppered and set into the alcohol in *D*. The control eggs were kept in water in covered embryological watch glasses.

The results of the experiment are given in table 10. The eggs of *Nematodirus filicollis* were not killed by one week's exposure to $-10°C$, and those of *Nematodirus spathiger* were not killed by two weeks at this temperature. The eggs of *Trichostrongylus vitrinus* were not killed by three days' exposure but none hatched after 12 days at $-10°C$. *Ostertagia circumcincta* eggs were not killed after 2 days in one experiment but in two other experiments there was no hatching after 1 day. In the cases of *Haemonchus contortus* and *Trichostrongylus extenuatus* no eggs hatched following 3 days at $-10°C$. The hatching results for *Cooperia curticei* and *Bunostomum trigonocephalum* were negative following 1 day exposure, and for *Cooperia oncophora* and *Chabertia ovina* following 3 days' exposure.

DISCUSSION OF THE EFFECT OF LOW TEMPERATURE ON THE EGGS

The results of the low temperature experiment indicate that infection with *Nematodirus* can appear in the spring sooner than that with some of the other parasites as the eggs of *N. spathiger* were not killed following two weeks' exposure to $-10°C$. Table 11 and figure 23 show the percentage of the total numbers of *Haemonchus*, *Ostertagia*, *Trichostrongylus*, *Strongyloides*, *Nematodirus* and *Cooperia*, obtained in each month, which

TABLE 10

EFFECT OF TEMPERATURE OF $-10°C$. ON HATCHABILITY OF EGGS OF SOME NEMATODES

Kind of Parasite	No. of Days eggs exposed to $-10°C$.	Hatching Results	Hatching of Controls
Haemonchus contortus	3, 4, 5, 6	−	+
Ostertagia circumcincta	2	+	+
	1, 4, 7	−	+
	1, 4, 7	−	+
Trichostrongylus extenuatus	3	−	+
Trichostrongylus vitrinus	3	+	+
	12	−	+
Nematodirus filicollis	4, 7	+	+
Nematodirus spathiger	14	+	+
Cooperia curticei	1, 13	−	+
Cooperia oncophora	3, 5, 5, 7	−	+
Bunostomum trigonocephalum	1	−	+
Chabertia ovina	3, 14	−	+

TABLE 11

THIS GIVES THE PERCENTAGE OF EACH OF THESE PARASITES MAKING UP THE TOTAL OBTAINED IN DIFFERENT MONTHS

Month	*Haemonchus*	*Ostertagia*	*Trichostrongylus* in abomasum	*Trichostrongylus* in intestine	*Strongyloides*	*Nematodirus*	*Cooperia*
June.........	2.5	30.3	21.8	14.5	2.9	19.1	8.9
July & Aug. 1.	18.7	36.3	0.6	4.7	8.6	26.9	3.9
Aug.30 & Sept.	20.1	12.9	3.6	9.4	5.5	27.2	16.2
October......	10.9	8.2	17.7	22.4	8.5	15.4	16.8
November....	1.5	5.0	43.6	22.2	6.6	5.7	10.4
December....	0.2	0.4	53.9	24.7	7.1	3.2	10.4
January......	0.5	0.8	39.7	38.5	6.2	11.4	3.0
February.....	+	4.7	38.8	24.8	3.6	14.0	14.2
March.......	0.9	9.2	38.5	22.6	6.7	4.8	17.5
April.........	5.3	15.4	53.4	8.6	6.7	5.1	5.6
May.........	5.3	19.3	49.3	10.3	3.5	2.1	10.5
June.........	0.4	31.5	3.9	0.8	5.6	39.9	18.0
July.........	16.2	47.7	1 8	1.2	5.1	21.5	6.5

belonged to these different genera. It will be noticed that in June a large percentage of the total was made up of *Nematodirus*, and *Ostertagia*. If the eggs of these parasites are not killed by our winter temperatures, and the results of the temperature experiment indicate that those of the former genera at least may not be, then the young animals could acquire infection with it early in spring. The conflicting results obtained for *Ostertagia* suggest that the eggs of this species may not be killed by our winter temperatures either. The finding of these parasites by Hadwen and Palmer (1922) in the reindeer in Alaska is further evidence that they will tolerate low temperatures. If the eggs and larvae of the different species have not wintered over on the ground then the rate at which the lambs can be infested in the spring, and the degree of infestation in them will depend on the number of animals put on the same pasture, the amount of infestation on these and the rate of egg production of the worms. If the eggs of *Trichostrongylus* and *Haemonchus* are killed during the winter it would be expected that infestation with the latter might be more rapid than with the former because of the much larger number of eggs contained in each adult female *Haemonchus* as compared to *Trichostrongylus*.

XII. SUMMARY

One hundred and forty-four lambs received from 24 counties in Ontario lying between the southern boundary, Picton on the east and Wiarton on the north, were examined for helminth parasites between April, 1935, and July, 1936.

Nineteen species of worms belonging to fifteen genera were found in these lambs. Eighteen of these species were nematodes and the other a cestode.

The incidence of infection was highest with *Haemonchus*, *Ostertagia*, *Trichostrongylus*, *Strongyloides*, *Nematodirus*, and *Cooperia* as was also the degree of infestation.

The number of parasites harboured by individual lambs varied from fifty to 22,788, with an average of 4,296, based on the results from 144 animals.

These different kinds of parasites were found in different situations in the host.

Trichostrongylus (the specimens in the intestine), *Strongyloides*, *Nematodirus* and *Cooperia* were found in the proximal 50 feet of small intestine, the maximum number for each occurring at different distances from the pylorus. The maximum numbers for *Trichostrongylus* occurred in the first two feet of the intestine, that for *Strongyloides* four to six feet from the pylorus, that for *Nematodirus* four to eight feet, and for *Cooperia* eight to twelve feet from the pylorus.

Bunostomum was found twenty to forty feet from the pylorus.

Moniezia occurred in greatest numbers forty feet or more posterior to the pylorus.

Nodules caused by *Oesophagostomum columbianum* were present in the wall of the small intestine throughout its length and in the caecum.

It is suggested the distribution of some of these parasites in the host may indicate their degree of adaptation to a parasitic life and the relative length of time they have been parasites. The food requirements no doubt have an important relation to the location occupied by the parasite.

There was a higher incidence of infection with *O. columbianum* among the older than among the younger animals. This was related to the longer exposure to infection of the older lambs.

The absence of *Moniezia* infection in February and March is thought to be related to its life cycle.

The different parasites showed a marked seasonal variation in numbers.

Infestation with *Haemonchus* and *Ostertagia* was heaviest in summer and lightest during late autumn and winter. *Nematodirus* and *Cooperia*

were also found in larger numbers in summer than in late autumn and winter, except for an increase in February.

Strongyloides was found in more uniform numbers throughout the entire year, although fewest were found in the young lambs examined in summer.

Maximum infestation with *Trichostrongylus* was found in the animals examined in winter.

It is thought the host may develop a temporary resistance against some species which would account for this variation in numbers. It would appear that it may be more temporary for *Nematodirus* and *Cooperia* than for *Haemonchus* and *Ostertagia* and that it is lacking or develops very slowly against *Strongyloides* and *Trichostrongylus*.

The differential effect of low temperatures on the eggs of some species may explain why infestation in young animals appears earlier in the spring for some species than for others.

Infection with *Nematodirus* may appear earlier in the summer than that with *Haemonchus*, as the eggs of the latter were killed by a three-day exposure to $-10°C.$, but the eggs of *N. spathiger* were not killed in two weeks at this temperature.

Eggs of *T. vitrinus*, *C. curticei*, *C. oncophora*, *B. trigonocephalum* and *C. ovina* were killed by a three day exposure to $-10°C$.

The average ratio of females to males was greater than unity in the case of *H. contortus*, *O. circumcincta*, *Trichostrongylus* and *Cooperia*, but less than unity in the case of *Nematodirus*.

All species, with the exception of *Dictyocaulus*, *Capillaria* and *Ascaris* had a wide distribution in the area studied, although they were not taken in every locality from which lambs were received.

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TABLE A

NUMBERS OF TRICHOSTRONGYLUS SPP. IN DIFFERENT TWO-FOOT SECTIONS OF SMALL INTESTINE

The numbers in each section are expressed as percentage of the total number of mature worms present in the animal

Lamb No.:	16	29	30	33	35	36	37	40	41
TOTAL NO. WORMS:	2,265	744	111	234	1,241	202	307	2,680	357
Section Number									
1	39.9	12.4	45.1	19.2	8.0	26.2	15.6	23.8	24.6
2	36.9	21.6	6.3	5.5	29.0	25.2	39.4	2.7	14.6
3	6.2	22.6	11.7	26.1	18.0	14.9	8.8	32.1	17.4
4	7.2	17.6	9.1	8.9	12.8	13.7	16.6	11.3	24.6
5	1.3	10.0	9.9	33.3	8.1	9.9	8.2	7.3	3.9
6	1.8	5.3	5.4	1.7	8.1	6.4	4.2	5.2	4.5
7	1.1	2.6	4.5	0.4	3.2	0.5	2.3	5.1	2.0
8	2.5	2.7	0.9	0.9	1.6	1.0	0.3	6.0	1.1
9	0.4	1.8	3.6	..	2.4	..	0.6	3.1	1.7
10	0.8	0.5	1.8	0.4	1.0	1.0	0.6	1.0	0.8
11	0.4	..	0.9	0.9	0.4	..	..	0.2	0.6
12	0.3	0.1	..	..	2.2	..	1.3	0.5	0.6
13	0.2	..	..	0.4	..	..	0.6	0.2	1.4
14	0.1	0.1	..	..	1.4	..	..	0.2	0.3
15	0.2	0.4	..	..	..	..	..	0.9	0.8
16	0.1	0.4	..	..	0.7	..	..	0.3	..
17	..	0.8	0.9	0.9	1.0	..	..	..	..
18	0.1	..	..	0 4	0.6	..	0.3	..	0.8
19	..	..	..	..	..	..	0.3	..	..
20	0.2	..	..	0.4	0.2	..	..	..	..
21	0.1	..	..	..	..	..	..	..	..
22	..	..	..	..	0.2	..	0.3	..	..
23	..	..	..	..	0.2	..	0.3	..	0.3
24	..	..	..	..	0.3	..	..	..	..
25	..	..	..	0.4	0.2	..	..	..	..

TABLE A—*Continued*

NUMBERS OF STRONGYLOIDES IN DIFFERENT TWO-FOOT SECTIONS OF SMALL INTESTINE EXPRESSED AS PER CENT. OF TOTAL NUMBER MATURE WORMS PRESENT IN THE ANIMAL

Lamb No.:	24	27	29	30	32	34	35	36	38	40	41
TOTAL NO. OF WORMS:	575	100	499	173	322	182	297	499	1,384	180	279
Section Number											
1	3.0	3.0	0.4	2.3	6.8	4.9	3.4	7.4	11.2	5.0	1.1
2	9.9	16.0	2.2	8.7	2.5	15.4	25.3	12.8	16.7	8.3	8.2
3	32.7	26.0	23.2	12.7	21.8	24.2	17.9	17.4	18.8	13.9	17.2
4	16.9	16.0	21.4	12.2	17.1	19.8	21.6	12.0	18.8	12.8	15.0
5	12.2	16.0	16.7	9.8	18 9	13.7	10.8	12.0	16.0	10 5	9.0
6	13.4	10.0	11.0	14.5	4.0	6.0	8.1	10.0	7.7	3.9	12.2
7	5.7	3.0	9.0	9.8	9.0	4.4	3.4	10.0	4.5	15.6	7.2
8	3.1	3.0	7.2	8.1	6.5	3.8	1.0	7.0	4.0	7.8	11.5
9	1.2	3.0	4.4	5.2	6.8	1.7	2.7	2.8	1.1	7.8	7.2
10	1.4	..	3.6	3.5	2.5	0.5	1.0	2.0	0.5	..	6.8
11	0.3	1.0	1.2	2.3	1.6	0.5	0.3	2.8	0.1	5.6	3.2
12	0.2	2.0	..	2.3	1.2	0.5	1.0	0.2	0.1	5.6	0.4
13	..	..	0.2	2.3	0.6	0.5	0.3	0.6	..	..	1.1
14	..	..	..	2.9	0.6	1.1	0.7	0.8	..	..	..
15	..	..	..	1.2	..	..	..	0.3	..	3.3	..
16	..	1.0	..	2.3	..	0.5	0.3	0.6	..	..	..
17	..	..	..	..	..	0.5	0.7	0.4	..	..	..
18	..	..	..	..	..	1.1	0.3	..	..	..	..
19	..	..	..	..	..	0.5	..	..	..	..	..
20	..	..	..	..	..	..	0.3	0.4	..	..	..
21	..	..	..	..	..	..	..	0.2	..	..	..
22	..	..	..	..	..	..	0.3	..	0.1	..	..
23	..	..	..	..	..	..	..	..	0.1	..	..
24	..	..	..	..	..	..	0.3	..	0.1	..	..
25	..	..	..	..	..	..	0.3	0.2	..	..	..

TABLE A—*Continued*

NUMBERS OF MATURE COOPERIA IN DIFFERENT TWO-FOOT SECTIONS OF SMALL INTESTINE EXPRESSED IN PER CENT. OF TOTAL NUMBER OF MATURE WORMS PRESENT IN EACH ANIMAL

Lamb No.:	19	21	29	30	31	33	34	35	36	37	38	40	41
TOTAL NO. WORMS:	617	507	117	123	239	138	996	2,531	120	329	509	3,270	786
Section Number													
1	0.2	5.5	..	..	..	..	0.7	1.1	0.8	..	0.4	..	..
2	1.3	14.8	0.9	..	0.8	..	1.7	7.4	6.7	7.6	0.8	0.2	..
3	15.9	17.1	..	..	0.4	5.8	6.3	10.8	22.5	6.7	0.6	0.9	..
4	18.2	13.6	2.6	17.1	0.4	2.9	11.6	15.8	24.2	8.2	7.5	1.6	..
5	14.7	6.1	5.1	8.1	1.7	50.7	18.7	15.1	17.5	6.7	21.8	1.7	2.2
6	7.9	13.0	2.6	23.5	2.1	12.3	23.6	13.6	13.3	5.2	13.8	3.4	4.9
7	6.2	8.1	6.0	9.8	2.9	12.3	13.4	11.1	5.0	11.3	22.2	12.4	9.3
8	5.8	6.1	9.4	11.4	2.1	6.5	8.0	8.8	7.5	7.9	14.4	23.1	20.7
9	3.9	5.7	18.8	10.6	5.0	4.3	3.8	8.7	1.7	7.3	10.0	22.6	17.3
10	6.2	3.3	29.0	7.3	5.0	2.9	1.3	2.7	0.8	4.9	5.7	13.3	17.4
11	6.8	1.8	13.7	2.4	2.1	1.4	1.6	0.4	..	7.9	1.8	8.1	10.4
12	4.5	0.6	3.4	2.4	5.0	..	2.3	3.5	..	6.7	0.8	2.3	4.9
13	0.6	0.4	2.6	1.6	13.8	0.7	3.7	..	..	4.3	0.2	0.9	5.5
14	1.5	0.2	..	0.8	4.6	..	1.3	0.5	..	1.5	..	4.4	3.7
15	1.9	0.2	0.9	2.4	11.3	..	0.8	0.1	..	0.3	..	2.7	2.0
16	1.1	0.2	..	0.8	4.0	..	0.5	..	..	4.2	..	1.1	0.9
17	1.1	0.4	..	..	12.1	..	..	0.1	..	1.5	..	0.4	0.3
18	0.3	0.6	..	..	14.7	..	0.1	..	..	2.4	..	0.4	0.4
19	0.6	..	..	0.8	5.9	..	0.1	..	..	3.3	..	0.4	..
20	0.8	..	..	..	1.3	..	0.1	..	..	2.1	..	..	..
21	..	0.8	..	..	1.3	..	..	..	..	0.6	..	..	..
22	..	1.0	..	0.8	..	..	..	..	..	..	..	0.2	..
23	..	0.2	0.9	..	..	..	..	..	..	..	..	..	0.1
24	0.3	..	4.3	..	2.1	..	..	..	..	..	..	..	..
25	..	0.2	..	..	1.3	..	..	..	..	..	..	..	..

TABLE A—*Continued*

MATURE NEMATODIRUS IN DIFFERENT TWO-FOOT SECTIONS OF SMALL INTESTINE EXPRESSED AS PER CENT. OF TOTAL NUMBER OF MATURE WORMS PRESENT IN THE ANIMAL

Lamb No.:	18	19	20	22	24	26	27	29	30	31	32	34	35	36	37	38	39	40	41
TOTAL NO. WORMS:	192	524	238	1,603	955	96	199	2,778	645	205	282	360	754	494	267	1,427	173	9,774	745
Section Number																			
1	0.5	17.4	1.7	0.6	0.1	2.1	0.5	..	0.5	9.3	2.8	1.1	..	17.6	5.2	0.1	2.9	..	..
2	2.1	34.6	17.2	0.4	1.4	15.6	9.5	0.1	6.4	10.7	1.6	2.2	6.5	17.8	23.9	1.9	0.6	..	..
3	8.9	43.0	32.3	0.2	30.3	20.9	8.0	0.2	24.4	11.7	28.0	2.1	24.8	12.4	9.0	3.8	7.5	0.5	0.1
4	18.8	3.4	29.8	13.4	22.0	31.3	16.6	1.2	27.3	8.3	14.5	6.7	24.2	20.9	16.5	19.8	16.2	2.2	1.5
5	15.1	0.2	9.7	20.8	18.7	11.5	14.1	5.4	5.6	17.5	15.9	5.6	24.8	11.5	13.5	32.3	16.8	5.2	2.9
6	12.5	0.7	6.3	40.0	15.3	1.4	7.0	7.6	5.9	9.2	7.4	7.5	12.9	10.1	6.4	19.6	6.4	9.8	7.1
7	11.5	..	1.7	0.2	4.1	2.1	11.1	15.3	4.7	6.8	4.9	7.8	2.5	4.9	7.9	11.1	8.7	17.0	7.4
8	8.3	..	0.4	15.4	2.5	7.3	15.1	22.6	3.4	4.9	4.3	11.7	1.6	1.6	7.5	4.9	10.4	13.9	20.0
9	10.4	0.3	..	3.8	1.3	3.1	5.5	21.3	1.7	1.9	3.9	8.9	1.5	2.0	2.6	2.5	4.6	15.4	15.1
10	3.1	..	0.4	2.0	1.8	3.1	4.0	14.3	2.5	2.4	2.8	3.1	0.7	0.2	0.4	1.4	7.5	13.2	8.0
11	3.1	..	..	1.6	0.8	..	5.5	6.7	2.2	1.5	1.4	4.7	0.2	0.2	1.1	0.5	4.6	6.8	8.4
12	0.5	..	0.4	0.3	0.4	..	1.0	2.3	2.0	1.5	1.4	5.6	0.4	0.2	2.6	1.1	1.7	2.8	6.7
13	3.1	..	..	0.6	0.3	1.4	0.5	1.2	0.8	1.5	0.7	11.2	..	..	1.1	..	3.4	2.5	7.5
14	0.5	..	..	0.6	0.1	..	..	1.0	2.5	1.9	1.7	13.3	0.4	0.2	0.4	0.1	0.6	3.1	4.4
15	..	..	..	..	0.2	..	..	0.3	1.1	1.9	1.1	1.7	..	..	..	..	..	3.5	5.6
16	1.0	0.2	..	..	0.3	..	..	0.1	1.1	1.9	1.7	2.5	..	0.2	0.4	0.1	..	1.3	0.8
17	0.5	..	..	..	..	..	..	0.3	2.6	1.5	1.1	..	..	..	0.4	..	0.6	1.9	2.5
18	..	0.2	..	..	0.1	1.4	0.5	..	3.0	0.5	1.1	1.4	..	..	..	..	0.6	0.7	1.5
19	..	..	..	..	0.1	..	0.5	..	0.3	1.9	1.7	0.5	..	..	0.4	0.1	..	..	..
20	..	..	..	..	..	..	..	..	..	1.0	0.7	0.5	..	..	0.4	..	1.2	..	..
21	..	..	..	..	0.1	..	..	0.1	0.3	..	..	..	..	..	..	..	0.6	..	0.1
22	..	..	..	..	..	..	0.5	0.1	0.5	1.5	1.1	0.5	..	..	0.4	..	0.6	..	..
23	..	..	..	..	..	..	..	..	0.5	1.0	..	0.5	..	0.2	..	..	1.7	..	..
24	..	..	..	..	..	..	..	..	0.1	..	0.4	..	..	..	..	0.1	1.2	..	..
25	..	..	..	..	..	..	..	..	..	0.5	..	0.5	..	..	..	..	1.7	..	..

NOTES ON SPECIMENS OF AMERICAN PLECOPTERA IN EUROPEAN COLLECTIONS

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The studies upon which these notes are based were made in late 1935 and early 1936, in the course of a visit to various European capitals. The collections of the following museums were examined:

Austria:	Naturhistorisches Museum, Burgring 7, Vienna.
Belgium:	Musée Royal d'Histoire Naturelle (including the collection of Baron E. de Selys Longchamps), Brussels.
Czechoslovakia:	National Museum, Prague.
England:	British Museum (Natural History), South Kensington, London.
	University Museum, Oxford.
France:	Muséum National d'Histoire Naturelle, 45 Rue de Buffon, Paris.
Germany:	Zoologisches Museum der Universität, Invalidenstrasse 43, Berlin.
Switzerland:	Musée d'Histoire Naturelle, Geneva.
	Musée de Neuchâtel, Neuchâtel.

Curators and assistants at the various museums were most obliging in placing at the writer's disposal not only their collections, but apparatus needful for the examination of the specimens. In addition, Mr. D. E. Kimmins of the British Museum spent a great deal of time in relaxing and mounting abdomens and wings, in order that accurate figures might be made of them; and he has since supplied additional helpful observations, particularly in resolving the confusion arising from the varied usages of the name *Chloroperla*.

The late Dr. P. W. Claassen of Cornell University had previously examined some of the British Museum types, and very kindly lent the writer his notes. In general his observations are confirmed by our own; in several cases they are cited specifically in the text to follow. Dr. Claassen had also read and criticized the manuscript of this paper, as has Dr. T. H. Frison, Chief of the Illinois Natural History Survey. To all who have assisted in any way in the preparation of the work the writer wishes to acknowledge his indebtedness.

The systematic arrangement followed is in the main that of Frison (1935), with the change of generic names noted in the text; but for convenience we follow Needham and Claassen (1925) in assigning sub-

generic rank to the species groups of *Taeniopteryx* (sensu lato). Specimens are listed under the genus to which we believe they belong, and the describer's original generic designation is given in brackets after the citation of his work, when it was different from that used here.

Failing a series of specimens for examination along with the various types, the Monograph of American Plecoptera by Needham and Claassen (1925) has provided the principal basis for the various comparisons made. The numerous references thereto are usually cited simply as "N. & C.".

1. *Pteronarcys biloba* Newman (1838: 176). In the case of this species, as with most *Pteronarcys*, little need be said after the review of Klapálek (1907), with its excellent illustrations, and the additional synonymy of Smith (1917). Newman's type ♀ is in the British Museum, labelled "Trenton Falls, N.Y.", and a male considered cotypic by Klapálek, taken by E. Doubleday, is probably from the same locality as the type. Both agree with the description of *biloba* by N. & C., p. 40.

2. *Pteronarcys californica* Newport (1848: 388, 1851: 450). The ♂ type is in the British Museum, and is as described in N. & C., p. 37.

3. *Pteronarcys frigida* Gerstäcker (1873: 65). The ♂ type is in the Zoological Museum of the University of Berlin, from "Labrador". Although synonymized with *dorsata* Say by Smith (1917), it proves to be the same as the more recently described *shelfordi* Frison (1934:25), as evidenced by its straight rather than dorsally directed tips of the 10th tergite. It differs from *nobilis* Hagen in the straight instead of downcurved tips of the 9th sternite, and in its larger size (expanse 79 mm.). The locality given suggests a northern distribution for the species; Frison's specimens were also from the north: Fort Churchill on Hudson's Bay. For excellent descriptions and figures of both sexes, see Frison's paper.

4. *Pteronarcys fumipennis* Klapálek (1907: 17). The ♀ type, from Washington Territory, is in the Vienna Museum; it has been rightly synonymized with the earlier *princeps* Banks (Smith, 1917).

5. *Pteronarcys insignis* (Pictet) (1842: 123- *Kollaria*). The type ♀, without locality label, is in Vienna Museum. It has been correctly synonymized with *regalis* Newman by Klapálek (1907), hence with *dorsata* Say by Smith (1917).

6. *Pteronarcys labradorensis* Šámal (1933: 95). The type ♀ is in the National Museum at Prague, from Matamek, Quebec Labrador. It is very close to *P. dorsata* (Say), and probably identical with it. The folds on the 8th abdominal sternite used by the describer to distinguish it appear to be incidental to drying.

7. *Pteronarcys picteti* Hagen (1873: 281). This name was proposed for a ♂ specimen from Binghampton, N.Y., described by Pictet (1842: 128) as *protaeus* Newman, and now in the Zoological Museum at Berlin. It proves to be synonymous with *dorsata* Say, rather than with *nobilis* Hagen, as suggested by Smith (1917).

8. *Pteronarcys proteus* Newman (1838: 177). From Klapálek's careful drawings of the ♂ and ♀ types in the British Museum, Smith (1917) was able to point out that the association of sexes by Newman is not the same as that of later workers. She selected the ♂ as lectotype, and the ♀ now has the name *comstocki* Smith. Considering the scarcity of *comstocki* in later collections, it is remarkable that this confusion should have arisen. Since ♂ *comstocki* is not known, the possibility of the ♀ *proteus* being dimorphic must be considered.

9. *Taeniopteryx* (*Taeniopteryx*) *maura* Pictet (1842: 361). Pictet's type was a ♀ from Pennsylvania, in the Berlin Museum; he had also a ♂ which he hesitated to associate with the type. Only fragments of these two specimens: wings, part of head and antennae, and a bit of thorax, remain at Berlin to-day. These afford no reason to question the current use of the name. Hagen (1861: 36) rightly points out that *T. maura* of Walker (1852: 179) is really *T. glacialis* (Newport); the specimens so included are in fact Newport's type series.

10. *Taeniopteryx glacialis* (Newport) (1848: 389, 1851: 451—*Nemoura*, subgenus *Brachyptera*). Of the six original cotypes, 2 ♂♂ and 3 ♀♀ are in the British Museum, and one ♂ has been sent to the Museum of Comparative Zoology, Harvard University. The type locality is St. Martin's Falls, Albany River, Hudson Bay, Ontario. Examination of the types shows that it is distinct from other known species. We designate as lectotype and lecto-allotype respectively the ♂ and ♀ British Museum specimens from which the following description and figures 1-7 were made.

Length to tip of hind wings, ♂, 9 mm.; to tip of fore-wings, ♀, 14.5 mm.; expanse, ♀, 28 mm. General colour blackish brown, the legs somewhat lighter. Yellow markings as follows: mandibles and ridge behind labrum of ♂; middle of mesosternum, inner margins of femora and (less distinctly) of tibiae, spot on the supragenital plate of ♀, outer half of subgenital plate of ♂.

Hind portion of head rugulose forward to the margins of the eyes, and to the border of a depressed area included in the ocellar triangle. Ocelli small, the interocellar distance about 3.0 times that between eye and ocellus. Lateral tubercles large, flat, rounded. Prothorax rugulose,

wider behind, its anterior width about equal to its length. Wings of ♀ (fig. 1) of normal size; length of Sc. 0.57 of total length of fore wing; no costal crossveins other than the humeral; Cu_1 giving off a long bowed undivided anterior branch, and a straight posterior one which is bifurcate near the tip. Fore wing of ♂ only 3 mm. long, narrow and with greatly reduced venation; hind wing 8 mm., also narrow and with reduced venation, its anal region almost lacking.

Male: Subgenital plate (figs. 2, 3) produced far beyond the 10th segment and genitalia, total length 2.5 times its greatest width; its rim upturned, ladle-like. The extended part is bent back on itself, inside, and is very hairy. No lobe at base of the plate. Supra-anal body divided into two erect processes (figs. 4-6); the anterior more slender, T-shaped, the cross piece at its tip having a median hump; the posterior heavier, also T-shaped, but with a depression in the middle of the cross piece. Subanal lobes consist of an elongate bluntly-rounded chitinous process above; below they have a chitinized side portion and are produced posteriorly into involved asymmetrical and mostly membranous projections. Cerci five-jointed, with a roof-like process of the 10th segment covering part of the basal one.

Female: Supragenital plate (fig. 7) produced backward beyond the tip of the 10th abdominal segment, to the 4th or 5th segment of the 9-segmented cerci. Eighth sternite with a narrow excavate subgenital plate set in front of its posterior border. Seventh sternite also slightly modified by having the central third of the posterior margin demarcated by non-chitinized notches.

Frison (1929: 373) has shown that Newport's name *Brachyptera* should be applied to a group of European species whose genotype is *trifasciata* Pictet, and which have erroneously been included in the *Taeniopteryx* sensu stricto of recent European authors. Because of the larger number of segments in the cerci, lack of a lobe at the anterior margin of the ♂ 9th sternite, and less copious branching of Cu_1, the present species cannot be included in subgenus *Brachyptera*, where Newport had it placed. It differs also from *Strophopteryx* Frison and from *Taeniopteryx* s.s. (=*Nephelopteryx* Klapálek). The writer is however insufficiently familiar with other divisions of the genus to make a definite assignation at the present time.

11. *Taeniopteryx* (*Strophopteryx*) *fasciata* (Burmeister) (1839: 875—*Semblis*). There is a ♀ specimen in Berlin labelled "Philadelphia, Zimmerman", which is probably to be regarded as a cotype. In Pictet's collection at Geneva is another ♀, from "Pennsylvanie". Both are *fasciata* of recent authors.

12. *Nemoura (Paranemoura) perfecta* Walker (1852: 191). The ♂ type, from Nova Scotia, in the British Museum, proves to be identical with the later described *punctipennis* Claassen (1923: 291).

It should be noticed that the subgenus *Paranemoura* N. & C. (p. 288) of which *perfecta* Walker becomes the type, is a more distinct branch of *Nemoura* (*s. l.*), as regards adult characters at least, than various groups currently recognized as genera in Europe. Its principal peculiarities are: eyes exceptionally large, and hind portion of head narrow; wings broad, the apical costal crossvein in both wings absent, but a costal crossvein is present shortly before the tip of Sc.; the 9th abdominal sternite of the ♂ lacking a ventral lobe.

13. *Nemoura* (*s.l.*) *albidipennis* Walker (1852: 191). The type ♀, from Nova Scotia, is in the British Museum. We are unable to associate it definitely with any other described species.

Length to tip of wings 7.5 mm. Colour uniformly brown, except the yellow coxae, trochanters, proximal third of the femora, and tarsi. Head width (excluding eyes) 1.2 times that of prothorax. Head now collapsed and sunken, so that details are not visible. Prothorax sparsely rugulose above; its posterior width 1.2 times its length, its anterior width 1.3; a very broad flange on the anterior margin, set off by a shallow groove. Wings uniform brownish hyaline, veins brown; venation typical of *Nemoura*.

Female: 7th adbominal sternite slightly produced and rounded; the posterior margin of the 8th produced over ¼ of the 9th (fig. 8), its margin sinuate, the median notch shallow and rounded, the lateral lobes smooth and bluntly rounded.

14. *Nemoura* (*s.l.*) *completa* Walker (1852: 191). The type ♂ from Nova Scotia, in the British Museum, proves to be identical with *N. glabra* Claassen (1923: 281), whose type locality is also in Nova Scotia. A genitalial mount showed the characteristic specific features.

15. *Leuctra ferruginea* (Walker) (1852: 183—*Nemoura*, sg. *Leuctra*). The 3 ♀ cotypes, from Nova Scotia, are in the British Museum. One of these is here designated lectotype, and used as basis of the description and figure below. We are unable to associated it definitely with any other known species.

Length to tip of wings 8.5 mm. Colour brown; the legs lighter and with a yellowish tint, but darker along their outer margins and at the tips of femora and tibiae. Head (excl. eyes) as wide as the prothorax; the frontal ridge bow-shaped, crenate posteriorly, and dark; occiput finely rugulose and with a shallow median depression. Ocelli distant

from eyes by 0.5 of interocellar distance. Prothorax rugose, except for a broad lateral border and a median stripe, these comprising 0.15 and 0.1 of the total width respectively; the angles rounded and the margins somewhat bowed. Wings uniform brownish hyaline, without markings.

Female: Subgenital plate (fig. 9) notched, the inner sides of the lobes bordering the notch slightly excavate, the ends of the lobes very broadly rounded, almost truncate.

16. *Leuctra tenuis* (Pictet) (1842: 375—*Nemoura*, sg. *Leuctra*). The ♂ type, from Philadelphia, is still in the Berlin Museum, but rather damaged: head and prothorax, one hind wing, and part of the abdomen remain. Enough of the genitalia are visible to show that it is either *truncata* Claassen or *tenuis* Pictet of N. & C. (p. 232). It is desirable to accept the latter determination.

The specimens included by Walker (1852: 182) in *N. tenuis* are still in the British Museum, and consist of the following assortment: (1) 5 specimens of *C. vernalis*, including Newport's 3 cotypes, (2) 1 ♂ 1 ♀ *Taeniopteryx nivalis* Fitch, from Salem, N.Y., and (3) 1 ♂ 1 ♀ *Allocapnia pygmaea* Burm., also from Salem, bearing the label *Nemoura nivoriandus* Fitch (a manuscript name). Lots (2) and (3) were presented by Fitch himself. Hagen (1861: 33) had seen a pair from lot (1), and pointed out their true identity. The New York specimens he had apparently not studied.

17. *Capnia opis* (Newman) (1839: 89—*Perla*, sg. *Chloroperla*). The ♂ and ♀ cotypes are in the University Museum, Oxford. Both are labelled "Newfoundland" and have an additional locality label not easily recognizable, possibly "Weston" or "Chuston".

Length to tip of wings: ♂ 3.0, ♀ 7.5; to tip of body: ♂ 4.5, ♀ 6.0; length of fore wing: ♂ 2.0, ♀ 6.0 mm. Colour mostly black; antennae, cerci and legs dark brown; wings lightly infuscated, veins brown.

Head (excluding eyes) about 0.8 of width of prothorax; eye-ocellar distance 3.5 times the interocellar. Prothoracic width about 1.5 of length; surface very lightly rugulose on either side, median depression weak or absent, marginal groove distinct before and behind, not evident at the sides. Fore wing venation of ♀ resembling the N. & C. figure (p. 385) of *C. vernalis*, but differing in having the humeral and *two* other C-Sc crossveins; the tip of Sc meets R_1 anterior to the R_1-R_2 crossvein by almost the latter's length. Hind wing of ♀ also resembles the figure, but has three C-Sc crossveins in addition to the humeral; the intercubital crossvein is slightly proximad of the Cu_1-M_1, the latter in line with the M-R_3. Wings of male abbreviated, reaching to the middle of the 5th abdominal segment. Abdomen elongate.

Male: The four terminal abdominal segments have been relaxed. These are fully chitinized dorsally, except a median area of the 9th (not including its anterior margin) and the cleft tenth. Tergites 7, 8 and to a lesser extent 9 with rather fine densely appressed hairs pointing inward and backward. Ninth sternite with a rounded posterior extension, whose edge is heavily chitinized, bearing at its tip a small bulbous process, the latter lacking any pointed prolongations. Subanal lobes short, blunt and without extra chitin, marked off from the rest of the segment by a deep notch. Supra-anal process now distorted, but apparently grooved dorsally, rather bluntly pointed, reaching almost to the anterior margin of segment 9.

Female: Abdomen with a broad median non-chitinized area extending from segment 2 back to include the anterior third of 9. In the chitinized area on either side of these segments is a rather large spot of irregular outline, slightly darker and lacking hairs. Eighth sternite with the posterior margin slightly convex, at its middle a narrow squarish unchitinized area resembling a notch. Sternite 9 unchitinized anteriorly for a third of its width, with a median point extending even farther backward; sternite 8 with a similar smaller weakly chitinized anterior area. Except as noted, abdomen villose, the hairs longer on the sides and toward the tip, longest on the 10th segment and subanal lobes. The median non-chitinized area above bears very fine hairs. Cerci long (at least 24 segments), hairy, more finely so toward the tip.

C. opis has not been recognized since originally described. The description and figures of *C. vernalis* of N. & C. (nec Newport) agree very well with the above. The originals have recently been compared with Newman's types by Dr. P. W. Claassen, who reports that they are identical. The writer has seen specimens of *opis* from Ontario Co., Ont., in the Royal Ontario Museum of Zoology.

18. *Capnia vernalis* (Newport) (1848: 388, 1851: 451—*Perla*, sg. *Capnia*). The types, in the British Museum, consist of a male and a female here designated lectotype and lecto-allotype, and also an abdomenless specimen bearing Barnston's manuscript label "*Perla vernalis*", all from St. Martin's Falls, Albany River, Hudson Bay, Ont. They were included by Walker (1852: 182) under *Nemoura tenuis* Pictet.

The size, general appearance, colour etc. of the two types is similar to *C. opis* (Newman); unfortunately a detailed description was not obtained. The genitalial characters of both sexes are however quite distinct.

Male: Ninth sternite produced into a plate posteriorly, this bluntly pointed, and bearing at its tip an elongate pear-shaped acute process

lying between the subanal lobes, this process with a second acute anterior projection dorsal to the sternite (fig. 10). Subanal lobes subacute, heavily chitinized on the inner margin, marked off from the sternite by a deep notch. Supra-anal process bent forward as far as the posterior margin of the eighth tergite, its distal third narrower in side view and hollowed out above, the tip sharply pointed (fig. 11).

Female: Eighth sternite (fig. 12), with a strongly chitinized posterior lip occupying a third of the width of the sternite, and set somewhat anterior to its hind margin. Dorsal to the lip is the chitinized roof of the genital aperture, indistinctly 4-lobed in front. The ventral lip and chitinized roof form the opening of a canal which may be distinctly traced back to the 7th segment's margin.

Two more of Walker's (1852) specimens called *Nemoura tenuis* Pictet prove to be of this species; they were taken at York Factory, Manitoba. The supra-anal process of the male is noticeably longer than in the type, extending to the middle of the 8th tergite.

19. *Allocapnia minima* (Newport) 1848: 388, 1851: 453—*Perla*). The cotypes consist of 1 ♂, 1 ♀ and 3 nymphs, in the British Museum, all from St. Martin's Falls, Albany River. Examination of the cleared genitalia of both sexes shows the species to be identical with *A. incisura* Claassen (1924: 45), known from New York, Maine and Nova Scotia (N. & C. p. 276).

20. *Allocapnia necydaloides* (Pictet) (1842: 326—*Perla* sg. *Capnia*). The type of Pictet is in the Vienna Museum, a ♀ lacking abdomen, and hence indeterminable as to species. Hagen has identified ♀ specimens of *Allocapnia* in several museums as *necydaloides*, but it is impossible that he could have distinguished the various species as now known. It seems best therefore that the name be allowed to lapse as no longer recognizable; it may even be synonymous with the earlier *pygmaea* Burmeister.

21. *Allocapnia pygmaea* (Burmeister) (1839: 874—*Semblis*). Needham and Claassen (p. 278) have already examined two cotypes of this species, and selected one as lectotype; the second they refer to *A. recta* Claassen, There as additional members of Burmeister's series in the University Zoological Museum of Berlin, including 2 ♂ *A. recta*, one ♂ *A. granulata* Claassen, and a ♀ lacking abdomen; all from Pennsylvania (Zimmerman).

22. *Atoperla ephyre* (Newman) (1839: 87—*Perla*, sg. *Chloroperla*) The type ♀ from Georgia, in the British Museum, has been accurately identified by later authors.

23. *Perlinella drymo* (Newman) (1839: 86—*Perla*, sg. *Isogenus*). The cotypes, two ♀♀ from Georgia, in the British Museum, have been accurately identified.

24. *Neoperla clymene* (Newman) (1839: 87—*Perla*, sg. *Chloroperla*). The type ♀ from Georgia, in the British Museum, has been correctly recognized.

25. *Neoperla occipitalis* (Pictet) (1842: 254—*Perla*, *s. s.*). Pictet mentions specimens in Berlin and Vienna. We were able to find only the former, a ♀ from Philadelphia. It has been rightly synonymized with *clymene* Newman as described by N. & C. (p. 134).

Hagen (1861: 25) recorded a specimen of the South American *dilaticollis* Burmeister (belonging to *Neoperla* or a related genus) in the Vienna Museum, as being from "North America". We were unable to locate such a specimen.

26. *Perlesta costalis* Klapálek (1921: 150). A specimen in the Prague Museum, labelled "Heyne, Texas; coll. v. d. Weele, leg. 1907; Cotypus" can be included in *placida* Hagen as described by N. & C. (p. 158), as they have already indicated.

27. *Perlesta virginica* var. *immaculata* Klapálek (1921: 150). There is a series in the Coll. Selys and in Prague, determined by Klapálek, but types have not been designated. To be included in *placida* Hagen as described by N. & C., as they have already indicated (p. 158).

28. *Acroneuria abnormis* (Newman) (1838: 177—*Perla*). The type ♀ in the British Museum is from Trenton Falls, N.Y. The description of N. & C. (p. 178) is applicable to it in every way. Dr. Claassen observed in the dry specimen a small median notch in the subgenital plate, but on relaxing it Mr. Kimmins finds that it is the result of the action of some insect pest. Otherwise the plate is entire, and scarcely produced.

29. *Acroneuria arenosa* (Pictet) (1842: 178—*Perla*, sg. *Acroneuria*). Pictet mentions specimens in Berlin, Paris and Neuchâtel Museums, of which the last two have become lost. The Berlin type is however still extant, and in the many-branched 2nd anal vein of the hind wing, the subgenital plate and colour, it agrees with the description of N. & C. (p. 180). Pictet knew only the ♀, but with the foregoing there is a ♂; both are from "Pennsylvania, Zimmermann".

30. *Acroneuria arida* (Hagen) (1861: 18—*Perla*). The species *immarginata* Say was included by Klapálek (1909) in *Acroneuria*. The specimens so identified are in Prague, 3 ♂♂ and 1 ♀. All appear to

be *arida* Hagen. Klapálek's drawing of the ♀ subgenital plate exaggerates somewhat a hump formed in drying.

31. *Acroneuria brevicauda* Klapálek (1909a: 234). Synonymized with *xanthenes* Newman by N. & C. (p. 194). The type, in the Prague Museum, resembles a small ♂ *A. arida* Hagen, but would require further study for final identification. A paratype ("Cotypus") is a ♂ *A. xanthenes*. Both are labelled "North Carolina, Morrison".

32. *Acroneuria clara* Klapálek (1917: 45). This name was erected by Klapálek for a ♀ specimen described and figured by him in 1909 (a) as *arenosa* Pictet, which came from Washington, D.C. It is in most respects indistinguishable from *A. abnormis* Newman as described by N. & C. (p. 178), particularly in the markings of the head, and in the large number (8 and 10 in the forewings) of crossveins beyond the cord. It is however small for that species (expanse 50 mm.), and has a distinctively notched subgenital plate (fig. 13). The latter is suggestive of, but more extreme than, the notched plate of one of the figures of ♀ *A. perplexa* Frison (1937: 80).

33. *Acroneuria difficilis* Klapálek (1917: 47). The type is in Prague, a ♂ from "North Carolina, Morrison". We can distinguish it from *abnormis* Newman only by its small size (expanse 43 mm.), although it is of course possible that relaxation of the abdomen would show other minor differences; the head pattern is the same, and crossveins beyond the cord are (9, 10) in the forewings, and the genital hooks are of the same general type. It may prove to be associated with *A. clara* Klapálek, and is certainly synonymous with *A. scabrosa* Klapálek, which see.

34. *Acroneuria eidmanni* Šámal (1933: 96). The ♀ type is in Prague, from Matamek River, Quebec Labrador. The subgenital plate does not differ from that of the type of *A. abnormis* (Newman) in London, and it is improbable that the somewhat darker colour of body and legs is any more than an individual, or at most a local, variation.

35. *Acroneuria evoluta* Klapálek (1909). The type ♀, from New Orleans, is in the Vienna Museum. The name is used for a distinct species by N. & C. (p. 186), and more doubtfully by Frison (1937: 79). Our study indicates that it is synonymous with *arida* Hagen, as earlier suggested by Frison (1935: 95). As compared with Frison's Kansas specimens, the subgenital plate is wide, comparatively deeply notched on the sides, and not declivitous.

This synonymy leaves the species *A. evoluta* Klap. of Frison (1937: 79) without a name. No new name need be proposed at the moment,

however, as it is possible that one of those whose position is inadequately known will be available.

36. *Acroneuria internata* (Walker) (1852: 152--*Perla*). The British Museum type ♀ is from "North America". N. & C. (p. 184) give a description applicable to the type. The subgenital plate has lobes somewhat more pronounced than those they show, and with their edges thickened (figs. 14, 15). If the ♀ figured by Frison (1935: 330) belongs here, it is evident that the subgenital plate of *internata* can exhibit considerable variation.

37. *Acroneuria lycorias* (Newman) (1839: 85 *Perla*). Newman mentions specimens in the British Museum and in F. W. Hope's cabinet. We were unable to locate the species in London, but Hope's specimen is now in the University Museum at Oxford, and may be named lectotype. It agrees with N. & C.'s description (p. 189) in every way; the subgenital plate is produced over about half of the 9th segment, and is truncate at the tip.

38. *Acroneuria pennsylvanica* (Rambur) (1842: 456—*Perla*). Klapálek (1909a) said the type was in the Selys Collection, but we were unable to locate it there; nor is it in Paris, where it might be expected. In Prague there is a pair from Harrisburg, Pennsylvania, bearing on the pins the labels "*Acroneuria pennsylvanica* Rambur" and "Plesiotypus", the latter, at least, by Klapálek. We take this to mean that Klapálek had compared them with the type. They are in fact *arenosa* Pictet as used here (not as used by Klapálek). Near them is a ♀ *arenosa* with labels "*Perla* (*Acroneuria*) *abnormis* Newm. *pennsylvanica* Ramb.", "Philadelphie", and "Mus. Paris". This may possibly be the missing type of *pennsylvanica*, as Hagen did in fact synonymize it with *abnormis* Newman; the French origin is also very suggestive. Klapálek's drawing of the subgenital plate of the type is characteristic of *arenosa*. All evidence available therefore points to the identity of *pennsylvanica* and *arenosa*, and the latter name has several months priority. Specimens determined as *pennsylvanica* in America are said by Frison (1935: 391) to be *abnormis* Newman, at least in part.

39. *Acroneuria ruficeps* Klapálek (1917: 55). The type is in Vienna, a ♀ from south Colorado. It resembles the earlier-described *pumila* Banks, a species *incertae sedis* to Klapálek. It also resembles *pacifica* Banks in everything but the curiously shortened wings, so may eventually be regarded as a synonym of that species.

40. *Acroneuria scabrosa* Klapálek (1917: 46). The type ♂ is in Prague, from Falls Church, Virginia. Klapálek regarded this as similar

to his *difficilis*; we believe them identical, and the name *scabrosa* has page priority. The only differences noticed between the two types are: *scabrosa* has fewer crossveins beyond the cord (4, 4 against 9, 10, in the fore wings); *difficilis* has less intense dark markings on the head, though the same pattern; the pronotum of *difficilis* is slightly shorter. Undue systematic value was given to small differences in the shape of the pronotum by Klapálek.

It is probable that *scabrosa* will prove to be the same as some species currently recognized under a different name. A close study of the genitalia is necessary.

41. *Acroneuria sonans* (Newport) (1851: 447—*Perla*, sg. *Acroneuria*). The type ♀, from St. Martin's Falls, Albany River, Ontario, is in the British Museum. Its head is off; the subgenital plate is asymmetrical and presumably abnormal, being slightly produced in an irregular curve on one side only. The single crossvein beyond the cord in the fore wing indicates that it is probably *lycorias* Newman or some related species, rather than *abnormis* Newman as indicated by Hagen (1861: 17).

42. *Acroneuria trijuncta* (Walker) (1852: 153—*Perla*, sg. *Acroneuria*). The type ♀ specimen in the British Museum is from Georgia, and has suffered more than its share of the vicissitudes of taxonomy. At present it is recognized as distinct by N. & C. (p. 183), the type and a specimen from Lake George, N.Y., being the only ones known. However, Dr. Claassen's notes on the type indicate that it has the many-branched 2nd anal vein in the hind wing which is characteristic of *arenosa* Pictet; the subgenital plate, if relaxed, would have an outline as in that species; hence *trijuncta* becomes a synonym of *arenosa*.

43. *Acroneuria xanthenes* (Newman) (1838: 178 – *Perla*). The ♂ and ♀ cotypes, from Georgia, are in the British Museum. N. & C. (p. 194) have already designated the ♀ as lectotype, and described it well. Dr. Classen identified the ♂ as *Togoperla kansensis* Banks.

44. *Claassenia arctica* (Klapálek) (1916: 59—*Adelungia*). The ♂ and ♀ types, from "Arctic America", are in the British Museum. Genitalia of this interesting species are shown in figures 16 and 17. The genus is represented in North America by this species and by the *Perla languida* of N. & C. (p. 100), known from Wyoming and Montana.

45. *Neophasganophora tristis* (Hagen) (1861: 22—*Perla*). A ♂ specimen in the Selys Collection, labelled "Washington, Sacken; *Perla tristis* Hagen; Typus", is *Togoperla media* (Walker). N. & C. (p. 103) have however designated as lectotype a specimen in the Harvard Museum, which they synonymize with *N. capitata* (Pictet).

46. *Togoperla immarginata* (Say) ? (1823: 164 *Sialis*). A ♀ from New Orleans, in the Vienna Museum, bears considerable resemblance to this species as recognized by N. & C. (p. 102). It was the basis of the description and figure of "*Acroneuria lurida* Hagen" in Klapálek (1909). However, Dr. T. H. Frison suggests (in a letter) that New Orleans is out of the normal range of *immarginata*.

47. *Togoperla media* (Walker) (1852: 145—*Perla*, sg. *Isogenus*). The type is in the British Museum, from St. Martin's Falls, Albany River, Ontario. Dr Claassen found that the abdomen of the specimen had been glued on to it, and did not belong to it originally. The head, thorax and wings are typical of *media* as used by N. & C., so the current determination can stand, at least pending further collecting in the type locality. Klapálek's (1923: 96) illustration of the abdomen is of course inapplicable to this name, being probably a ♂ *Isogenus*.

48. *Perla decisa* Walker. (1852: 170– *Perla*, sg. *Chloroperla*). Placed in *Isoperla* by Banks (1907: 13), and in *Isogenus* (?*Isogenoides*) by Klapálek (1912: 61), examination of the relaxed abdomen shows that the type ♂ belongs to the group of species, included under *Perla* by N. & C., which have the 7th abdominal sternite produced into a nail. It comes from St. Martin's Falls, Albany River, Ontario, and is in the British Museum.

Length to tip of wings 12.5 mm. General colour yellow and brown. Head mostly brown, with yellow spots between the eyes and posterior ocelli, on the front of the head from the M-ridge almost to the edge of the labrum, filling most of the ocellar triangle, and projecting backward and outward therefrom in a narrow line on each side. Antennae and palpi brown. Prothorax with brown borders, and disc at least partly yellow (the pin obscures the central area). Meso- and metanotum mostly brown, with a few yellow spots; sides of the thorax brown, the sterna yellow. Leg segments brown, tending to yellow along the inner margins. Abdomen and cerci brown above and below, the "nail" of the 7th sternite yellow.

Front margin of pronotum apparently convex anteriorly. Wings hyaline with a faint yellowish cast. In the forewing: Sc terminates before the cord; 4 costal crossveins before its tip, 3 beyond; Cu-A crossvein distant from the anal cell by more than its own length; the two branches of A_2 arising independently from the anal cell.

Male: 7th sternite with the hind margin sinuously produced into a yellow nail (fig. 18); 9th sternite only slightly extended posteriorly. Dorsally the segments are normal to the 8th. The 9th has its posterior border produced at each edge, so that the central part of the tergite is narrow longitudinally. The 10th tergite is cleft, its inner posterior

margins produced into rounded processes, weakly chitinized and crenulate on the inner edges (fig. 19). Supra-anal process approximately U-shaped, with a slender sharp hame-like process on either side below; it is attached to a black basal support having three short blunt projections anteriorly. Subanal lobes of cerci of normal form.

In N. & C.'s key to *Perla* this species runs to couplet 14. The genitalia are similar to their *P. aestivalis*, or to *P. verticalis* Banks, and one of these may be synonymous.

Pending agreement as to what shall be the genotype of *Perla*, we retain this species there.

49. *Perla olivacea* Walker (1852: 144—*Perla*, sg. *Isogenus*). Like the last, this species springs from St. Martin's Falls in northern Ontario; it has not been recognized from any more southerly locality by modern students. Walker described only a single ♂, but among his specimens of *Isogenus frontalis* there was a ♀ from the same locality, which agrees so well with *olivacea* in details of colour and venation that we have little hesitation in describing it here as neo-allotype. There is also a ♂ in the Vienna Museum labelled "Hudsons Bai, 1881".

Length to tip of wings: ♂, 14 mm.; ♀, 20 mm. General colour dark brown with yellow markings. Head yellow below, brown above with a yellow triangular or bee-hive shaped spot on the occiput, extending forward to the frontal suture; posterior margin yellow. Ocelli with black rings on inner sides. Prothorax brown above and below, except a median dorsal yellow stripe of width about 0.07 of the whole. Below, the meso- and metathorax have a conspicuous pattern of yellow and brown; coxae brown, trochanters yellow (except on hind legs), remainder of legs brown. Abdomen blackish brown, with yellow near the tip in the ♀.

Frontal M-ridge bare and brown; ocelli slightly closer to the eyes than to each other; lateral tubercles well-developed. Prothoracic width about 1.8 times its length in front, behind rather narrower; all angles subacute; anterior and posterior grooves well developed; rugose on the disc. Wings brownish-hyaline, with brown veins; a faintly darker spot about the cord near the costal margin. Sc approaches closely to C for some distance, then diverges before finally running out into it. Costal crossveins before tip of Sc 5 to 7, beyond it 1 or 2. Cu-A crossvein in fore wings very short, distant from the anal cell by rather more than the length of the A_1-A_2 crossvein. Fork of A_2 outside the anal cell in one fore wing, in others the two branches leave the cell at the same point, or only slightly separated. Intercubital crossveins of hind wing 5 or possibly more.

Male: 7th abdominal sternite with a broadly rounded yellow nail on the hind margin (fig. 20); 9th sternite only slightly prolonged. Dorsally the abdominal segments are normal to the 7th. The 8th tergite is somewhat excavate on either side of the posterior margin; it is elevated near the middle, and on the downward-sloping posterior half bears numerous spinules (figs. 21, 22). Ninth tergite broadly and deeply notched from behind, its width at the centre only a third of that at the sides; its anterior margin sinuate; on the narrow central portion is a short transverse shelf overhanging the steep slope down to the depressed anterior margin. Tenth tergite cleft, much depressed anteriorly, the posterior inner corners enlarged and elevated into a pair of villose knobs bearing spinules on their anterior faces. Supra-anal process in two parts: (a) a broad section originating under the anterior corners of the 10th tergite, running downward and backward to the posterior margin of the segment; at its end is erected (b) a complex structure (figs. 22, 23) terminating in a long lash. Subanal processes, from the bases of the cerci, modified into two parts: a posterior and outer section, concave, meeting its fellow to form a hood over part (b) of the supra-anal process; and an anterior or inner section, directed downward and forward and with a chitinous inner margin which at its tip touches part (a) of the supra-anal process.

Female: Subgenital plate produced over half of the 9th segment, its sides rounded, a small obtuse notch in the middle (fig. 24) tip of the plate, most of 9th sternite, and posterior half of 10th sternite and tergite whitish yellow.

The prevailing dusky tint of this species is probably the reason for its placement in *Isogenus* by Walker, and the nail on the abdomen moved Klapálek to keep it there. We were unable to determine definitely whether or not there were submental gill remnants on any of these specimens—a character said by Frison (1935: 416) to distinguish Perlodidae from Perlidae in his restricted sense. The abdominal nail above-mentioned is much less like *Isogenus* than it is like certain species of *Perla* (e.g. *decisa*), so we tentatively retain it in that genus. The ♂ genitalia are very distinctive.

50. *Perla postica* Walker (1852: 144—*Perla*, sg. *Isogenus*). The type in the British Museum, from the MacKenzie River, northwestern Canada, lacks its abdomen and the wings are somewhat damaged. Dr. Claassen noted that there are four costal crossveins beyond Sc in the forewing more than in the specimens from the eastern U. S. A. determined as *postica* by N. & C. (p. 82). He regarded these determinations as probably erroneous. The colour of head and prothorax is rather similar

to *olivacea* Walker, but the venation is unlike that species. We were unable to distinguish, but hesitate to affirm the absence of, submental gill remnants. It will probably prove impossible to recognize the species with certainty, at least until additional material is at hand from the same region as the type.

51. *Isogenus frontalis* (Newman) (1838: 178—*Perla*, sg. *Isogenus*) Two types of Newman are in the British Museum, from Trenton Falls, N. Y.; both have lost their abdomens. Two ♂♂ taken at the same place and by the same collector (Foster) are complete; the supra-anal process of one of them is visible, and resembles the drawing of N. & C. almost exactly. Also in the British Museum is a ♀ from "Hudson's Bay" (St. Martin's Falls?), having a subgenital plate as in the N. & C. *frontalis*; it is one of Walker's series. A second ♀ of Walker was described under *olivacea* above.

52. *Perlodes* (*Arcynopteryx*) *americana* (Klapálek) (1912: 21—*Arcynopteryx*). The type will probably be found in Deutsches Entomologisches Institut at Berlin-Dahlem. We have seen paratypes ("Cotypen") as follows: 4 brachypterous ♂♂ from S. Colorado in the Vienna Museum, and one ditto at Prague. These may possibly be what is recognized under this name by N. & C. (p. 61), although they do not mention brachyptery. Examination of the relaxed genitalia is necessary for a decision on this species.

53. *Perlodes* (*Arcynopteryx*) *minor* (Klapálek) (1912: 22—*Arcynopteryx*). The types, a pair from "Arctic America", are in the British Museum. In Berlin there are 7 ♂♂ and 5 ♀♀ collected at Tikeräkdjuak, Nettilling Lake, Baffin Land, from July 12 to 22, 1910. Figured here are the ♂ genitalia, from the type and the ♀ subgenital plate, drawn from one of the Berlin specimens (figs. 25-27). *P. minor* is one of a group of closely-related species including *compacta* McLachlan, the type of *Arcynopteryx* Klapálek, which is here considered as a subgenus of *Perlodes* Banks.

54. *Hastaperla oculata* (Klapálek (1923b: 29—*Isopteryx*). There are two types, one in Vienna and one in the Selys Collection, both labelled "Trenton Falls, N. Y., von Sacken, 1858". Both have lost their abdomens. There is nothing to distinguish them from *H. brevis* (Banks), a widely distributed species. For the use of the name *Hastaperla*, see No. 61 below.

55. *Isoperla citronella* (Newport) (1848: 388, 1851: 450—*Perla*). Newport's two types consist of a ♂ and a ♀ from St. Martin's Falls,

Albany River, Ontario. To these Walker (1852: 170) added a ♀ *Alloperla* from Nova Scotia, quite different from the types. All three specimens are in the British Museum.

Length to tip of wings: ♂ 11 mm., ♀ about 12 mm. General colour yellow; on the head is a transverse ellipsoid brown spot in the region of the anterior ocellus, and sending narrow projections back to the posterior ocelli; ocelli narrowly ringed with black; the antennae yellow near the base, brown near the tip. Pronotum yellow, with broad brown stripes on either side enclosing a narrow mid-line. Mesothorax yellow above and below,; metathorax brown. Fore and middle legs yellow, tarsi darker (hind legs off). Wings clear hyaline, the veins scarcely coloured. Abdomen entirely brown, the posterior borders of the segments a little lighter. (The above colour description refers to the ♂; the ♀ differs as follows: (head absent); mesothorax with brown marking on the yellow above; metathorax yellow below; the hind legs yellow with a narrow brown band at the tip of the femur, the first tarsal segment conspicuously brown, the second yellow; veins of the wings much darker; abdomen yellow below, brown above).

Hind ocelli slightly closer to the eyes than to each other. Branches of A_2 arise separately from the anal cell in the fore-wing. Pronotum quadrangular, the angles subacute.

Male: 8th abdominal segment with a well-developed nail on its posterior ventral border (fig. 28). Ninth sternite produced and subtruncate in ventral view (fig. 29). The subanal lobes blunt, not modified into hooks.

Female: 8th sternite very slightly produced, its border shallowly emarginate (fig. 30).

The relation of these specimens to other American species will probably remain obscure until additional material is available from far northern Ontario. The differences in colour noted, particularly of the wings, suggest the possibility of incorrect association of the sexes; to meet this contingency, we designate the ♀ as lectotype, as being most likely to be recognized later; its subgenital plate differs somewhat from any one figured in the literature to date. The ♂ goes to *bilineata* Say in the N. & C. key (p. 145), and to that species or *richardsoni* Frison in Frison's (1935: 434), but is not either of these.

56. *Isoperla decolorata* (Walker) (1852: 170—*Perla*, sg. *Chloroperla*). The two British Museum types are from Great Bear Lake, northwestern Canada. One is a ♀, the other lacks its abdomen; both are much shrivelled and faded. The general appearance is that of *I. bilineata* Say, and the triangular subgenital plate (fig. 31), with its slightly notched

tip, is similar to one form of *bilineata* as figured by Frison (1935: 330). Additional material might show that the name should be sunk under Say's earlier one.

57. *Isoperla transmarina* (Newman) (1836: 499, 1839: 87—*Perla*, sg. *Chloroperla*). The ♀ type, in the British Museum, is from "North America".

Length to wing tips 13 mm., expanse 23 mm. Head with a pattern of brown on yellow (fig. 32). Prothorax brown, with a median yellow stripe of width 0.2 of that of the notum at its middle, wider at either end; there is also a very narrow lateral marginal yellow stripe. Meso- and metathorax brown above with yellow markings. Abdomen yellow above, with a broad median brown stripe extending to the 9th segment; yellow below and on the sides.

Head (excluding eyes) as wide as the prothorax; ocellar triangle nearly equilateral, the hind ocelli slightly closer to the eyes than to each other; lateral tubercles small, light brown, elliptical; frontal M-ridge represented only by two faint elongate elevations in front and to the side of the anterior ocellus. Prothorax quadrangular, angles subacute; the disc only faintly rugulose. Wings hyaline, veins brown; one intercubital crossvein in each hind wing, no costal crossveins beyond the cord in the fore wing, branches of A_2 rise separately from the anal cell.

Female: Subgenital plate a triangle with sides slightly indented and tip rounded-truncate (fig. 33); its length equal to about 0.3 of its own segment, and produced over about a third of the 9th.

Synonymized with *bilineata* Say by Hagen (1861: 30), the type is evidently not that species as now understood. We are unable to associate it definitely with species currently recognized in America, though this may later be done.

58. *Isoperla clio* (Newman) (1839: 86—*Perla*, sg. *Isogenus*). Newman's two ♂ specimens in the British Museum are types also of N. & C.'s genus *Clioperla*; they are from "Canada". N. & C.'s description and figures apply fairly well to them. There are two intercubital crossveins in all but one of the hind wings, one in that one. One of the abdomens has been relaxed: the 8th sternite has a bow-shaped margin the middle part slightly raised and bearing shorter stouter hairs than the rest of the venter. Ninth segment produced into a broadly-rounded plate, reaching to the tips of the subanal lobes. Above, the 9th segment bears, near its posterior border, two small squarish patches of spinules separated by an unarmed mid-line. The 10th tergite has a few spines adjacent to two chitinized and rather heavily armed ridges on its hind margin, these separated by a median more membranous area. Subanal lobes triangular, obtusish, not modified.

61. *Isoperla holochlora* (Klapálek) (1923b: 28—*Chloroperla*). There are four specimens so labelled in the Selys Collection at Brussels. Of these, one ♀ is probably not of the same species as the rest, being considerably smaller (L. 10.5 mm.) and having the subgenital plate differently shaped. Another ♀, here designated lectotype, is 14 mm. long to wing tips, and is the basis of the description to follow. Two ♂♂ (L. 12.5 mm.) are probably to be associated with the type ♀. All are from "Georgia, Morrison".

Colour intense yellow with light brown markings. Head yellow; ocelli narrowly ringed with black; a brown spot fills the ocellar triangle, its sides parallel, its front square, its hind margin slightly bowed to rear; 1st four segments of antennae yellow, the rest brownish; palpi yellow, their last segment brownish; clypeus brownish (except in one ♂). Prothorax with a yellow median stripe 0.1 to 0.2 of the total width, widened to rearward; its disc lightly marked with brown, its sides with a narrow yellow stripe; anterior groove and flange entirely brown, except at the mid-line. Remainder of thorax yellow; head and thorax yellow below. Legs yellow; a narrow terminal band on outside of the femora, and tips of tarsi, dark. Abdomen yellow above and below, the terminal sternites of ♀ and one ♂ darker; tails brown in ♀, yellow in ♂.

M-line of the head with the ascending (inside) branches broad, the descending ones very narrow. Pronotum with front and rear margins bowed out, all angles subacute; the disc rugose, marked off from the median stripe by distinct grooves. Wings with a distinct yellow cast, the veins yellow. In two hind wings there is one intercubital crossvein each (other wings are not visible).

Female: Subgenital plate broadly triangular, with straight sides and subacute apex (fig. 34).

Male: Lobe of the 8th sternite well developed, its sides slightly emarginate, its tip flattish, almost truncate. A broad heavily-chitinized band is contiguous with the posterior margin of the segment at either side, and bowed anteriorly in front of the lobe (fig. 35).

62. *Isoperla irregularis* (Klapálek) (1923b: 28—*Chloroperla*). Klapálek's holotype and two paratypes in the Vienna Museum prove to be ♀♀, taken April 12 to 23, 1875, with the labels "Boll, Texas". There is also a ♂ in the same museum, taken Apr. 14, 1875, in the same locality, which may serve as neo-allotype.

Length to tip of wings; ♀ 10-11 mm., ♂ 10 mm.; expanse: ♀ 17-19 mm., ♂ 17 mm. Colour brown and yellow. Head mostly brown, with small yellow spots at the base of the antennae, beside each eye, and in the middle of the ocellar triangle; the latter is confluent with a yellow

band across the hind part of the head, which band is interrupted by a faint brown stripe running back from each posterior ocellus; there is considerable variation in the relative areas occupied by brown and yellow. Yellow stripe of the prothorax about 0.2 of total width, wider posteriorly; disc brown; a narrow dark line fills the anterior marginal groove, extending even across the median stripe. Meso- and metathorax brown above (except on their hind margins) and on the sides; head and thorax yellow below. Legs brown, except the coxae, trochanters and lower surface of femora, which are yellow. Abdomen yellowish brown above, darker on the sides, and yellow below except the basal half of the subgenital plate; ♂ abdomen brown above and below, the hind margins of the sternites broadly ringed with yellow.

Ocellar triangle nearly equilateral; the interocellar distance 1.3 times that from eye to ocellus. Prothoracic width 2.0 times length; front and rear marginal flanges distinct; disc rugose. Wings brownish hyaline, veins brown. Crossveins beyond the cord two or three in the forewing; Rs with two or three branches; branches of A_2 come separately from the anal cell. Intercubital veins of hind wing two or three; in the ♂ one and two; middle segments of the tails with a long spine on the posterior border.

Female: 8th sternite produced over about half of the 9th segment (in the dried type it covers it), its hind margin thickened and very slightly emarginate in the middle (fig. 36).

Male: 8th sternite with a well developed nail (fig. 37); the subanal lobes cannot be distinguished without relaxing.

The species evidently belongs in the *Clioperla* group, but is none of those recognized by N. & C. as such. In Frison's (1935: 434) key to Illinois *Isoperla* it goes to *mohri* Frison, and the secondary sexual characters of both sexes appear to agree quite well; but the details of colour do not.

63. *Alloperla cydippe* (Newman) (1839: 88—*Perla*, sg. *Chloroperla*). The two British Museum cotypes are females from Georgia. One of them, here designated lectotype, is used for the description and figure to follow:

General colour (dry) yellow. Length to tip of wings 7mm., expanse 12.5 mm. Head (excluding eyes) not as wide as the prothorax; ocelli black; interocellar distance 2.0 times that from eye to ocellus; antennae mostly brown, yellowish near the base. Prothorax elliptical, rugose; the broad complete marginal flange separated by a narrow faintly brownish groove from the disc. Wings hyaline, the vane apparently greenish, the veins chloral green. Forewing: Sc ends much before the

cord; 3 costal crossveins before the tip of Sc, one beyond; A_2 branched outside the anal cell, but in one wing the distal branch goes forward to meet A_1, rather than descending to the margin. Hind wings: Rs once forked; anal field small but distinct; A_1 nearly as long as Cu_2, A_2 and A_3 well developed. The subgenital plate (figure 38) is produced over nearly half of the 9th abdominal sternite, its tip bluntly pointed.

The *Chloroperla cydippe* of Needham and Claassen (p. 128) is not the same as *cydippe* Newman. Their *cydippe* must therefore take the name of a former synonym, *brevis* Banks. Professor N. Banks and Dr. L. J. Milne kindly checked this synonymy by re-examining the types of *brevis* at the Museum of Comparative Zoology. These consist of two abdomenless specimens from Sherbrooke, Quebec, which agree in colour and venation with "*cydippe*" of N. & C.

It should be noticed that N. & C.'s use of the generic name *Chloroperla* Newman is inaccurate. In applying it to the species *brevis* Banks, they associated it with certain peculiarities of venation not found in related genera, notably a reduction of the anal veins in the hind wings. European species of *Chloroperla* have however been illustrated as having normal anal venation by Klapálek (1909b) and Petersen (1910), albeit under the synonymous name *Isopteryx* Pictet (for this synonymy see Banks 1906, and Kimmins 1936). As suggested by Frison (1937: 92) therefore, the generic name *Hastaperla* Ricker (1935), though founded on a misapprehension, must be used in place of the *Chloroperla* of N. & C., to contain the species *brevis* Banks and *orpha* Frison, the only species of this type known to date.

A further question arises concerning the use of the name *Chloroperla* in America. The genotype of *Chloroperla* Newman, which is *C. tripunctata* (Scopoli) as shown by Kimmins (1936), would key to *Alloperla* Banks in N. & C.'s key (p. 48); and none of the distinguishing characters of *Alloperla* given in published descriptions would exclude the European species of true *Chloroperla* Newman. Dr. P. W. Claassen had obtained material of *Chloroperla* from the British Museum, and in a letter written shortly before his death advised the writer that he had come to the opinion that *Alloperla* Banks should be made a synonym of *Chloroperla* Newman. It is not because of disagreement with this conclusion that the writer uses *Alloperla* in this paper, but rather as a measure of caution. No confusion can result from the continued use of *Alloperla* in America, temporarily at least. Adoption of *Chloroperla*, a name which has been applied to three different generic groups, would add greatly to existing confusion, were future work ever to make it necessary to separate the European and American forms.

The differences in venation between the genera under discussion may be summarized as follows:

Chloroperla Newman (*Isopteryx* Pictet) *Alloperla* Banks	*Hastaperla* Ricker (*Chloroperla* auct. americani)
(1) In the hind wing, A_1 nearly as long as Cu_2 and close to it for its entire length; A_2 with two well-developed branches.	In the hind wing, A_1 less than half as long as Cu_2, its tip diverging from it; A_2 represented by a single short rudiment.
(2) Anal field of the hind wing folding along the line between Cu_2 and A_1.	Anal field of the hind wind not folding between Cu_2 and A_1.
(3) Rs of the hind wing forked.	Rs of the hind wing simple.
(4) A_2 of the fore wing forked.	A_2 of the fore wing usually simple.

Of several American species described from European collections we failed to find any kind of type specimen. Pictet's types of *Perla capitata* and *P. coulonii* could not be found in the Neuchâtel museum, and Professor Fuhrmann writes that he has searched everywhere for them. Similarly *Perla picta* Pictet and *P.* (*Chloroperla*) *guerini* Pictet, supposed to be in the Pictet collection of the Geneva museum, are not there now, and have probably become corrupted after the usual fashion of earthly treasures. *Isopteryx rostellata* Klapálek was not found in any collection examined. Navás' two species, *Pteronarcys lobata* and *Perla uncinata*, are presumably in his own collection at Zaragoza.

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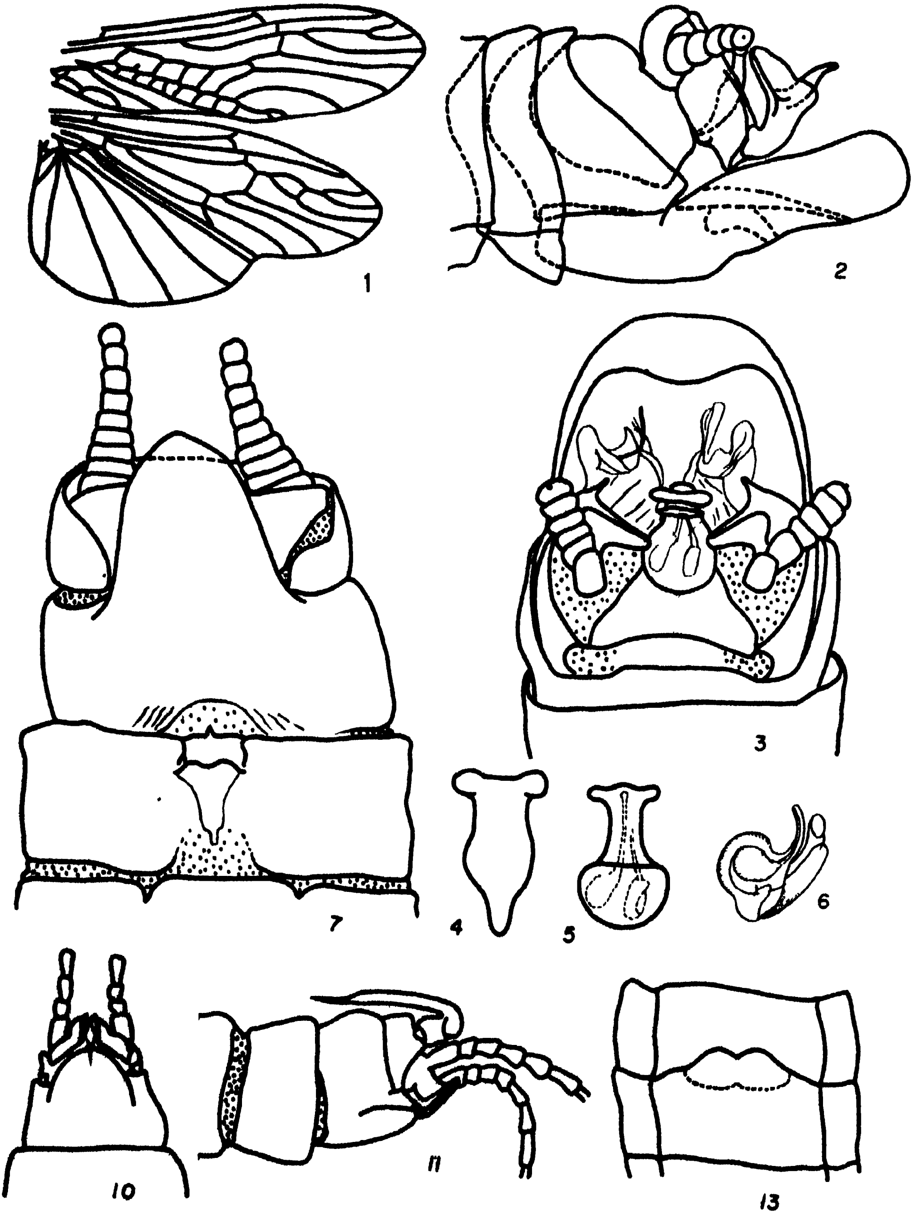
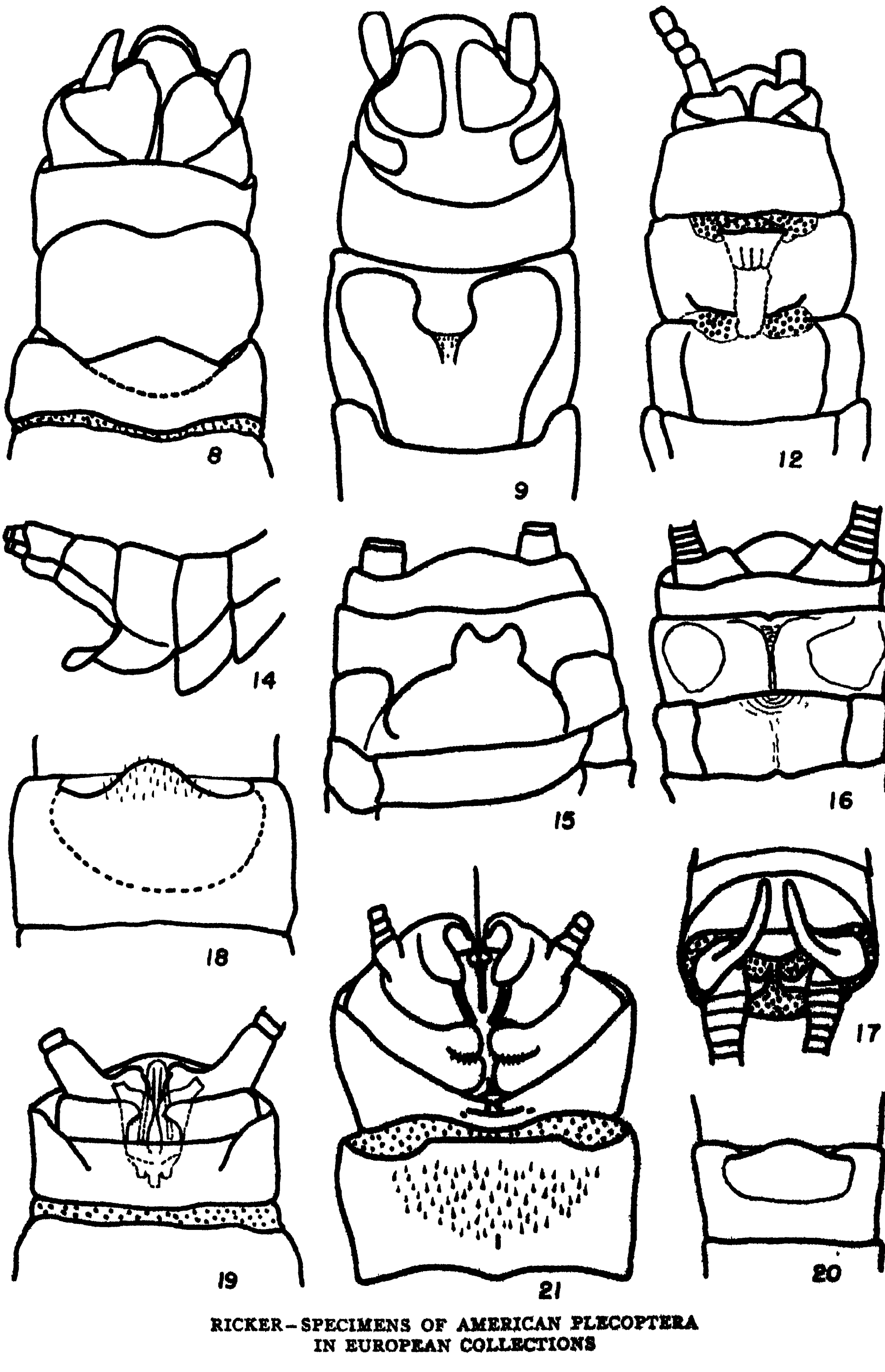
EXPLANATION OF FIGURES

1. *Taeniopteryx glacialis* (Newman). Wings of lecto-allotype ♀.
2. *T. glacialis.* Abdomen of lectotype ♂, from the side. (Relaxed).
3. *T. glacialis.* Abdomen of lectotype ♂, from above. (Relaxed).
4. *T. glacialis.* Posterior part of supranal process of lectotype ♂, from the front.
5. *T. glacialis.* Anterior part of supra-anal process of lectotype ♂, from the front.
6. *T. glacialis.* Supra-anal process of lectotype ♂, from the side.
7. *T. glacialis.* Abdomen of lecto-allotype ♀, from below. (Relaxed).
8. *Nemoura albidipennis* Walker. Abdomen of holotype ♀, from below. (Relaxed).
9. *Leuctra ferruginea* (Walker). Abdomen of lectotype ♀, from below. (Relaxed).
10. *Capnia vernalis* (Newport). Abdomen of lectotype ♂, from below. (Relaxed).
11. *C. vernalis.* Abdomen of lectotype ♂, from the side. (Relaxed).
12. *C. vernalis.* Abdomen of lecto-allotype ♀, from below. (Relaxed).
13. *Acroneuria clara* Klapálek. 8th and 9th segments of abdomen of holotype ♀, from below. (Dry).
14. *Acroneuria internata* (Walker). Abdomen of holotype ♀, from the side. (Dry).
15. *A. internata.* Abdomen of holotype ♀, from below. (Dry).
16. *Claassenia arctica* (Klapálek). Abdomen of allotype ♀, from below. (Dry).
17. *C. arctica.* Abdomen of holotype ♂, from above and behind. (Dry).
18. *Perla decisa* Walker. 7th abdominal sternite of holotype ♂. (Relaxed).
19. *P. decisa.* Abdomen of holotype ♂, from above. (Relaxed).
20. *Perla olivacea* Walker. 7th abdominal sternite of holotype ♂. (Relaxed).
21. *P. olivacea.* Abdomen of holotype ♂, from above. (Relaxed).
22. *P. olivacea.* Abdomen of holotype ♂, from the side. (Relaxed).
23. *P. olivacea.* Supra-anal process of holotype ♂, from the right side.
24. *P. olivacea.* Abdomen of neo-allotype ♀, from below. (Dry).
25. *Perlodes minor* (Klapálek). Abdomen of holotype ♂, from above. (Relaxed).
26. *P. minor.* Abdomen of holotype ♂, from the side. (Relaxed).
27. *P. minor.* Abdomen of a ♀ in the Berlin Museum. (Dry).
28. *Isoperla citronella* (Newport). 8th abdominal sternite of lecto-allotype ♂, from below. (Relaxed).
29. *I. citronella.* Tip of abdomen of lecto-allotype ♂, from below. (Relaxed).
30. *I. citronella.* 8th and 9th sternites of lectotype ♀. (Relaxed).
31. *Isoperla decolorata* (Walker). 8th and 9th sternites of lectotype ♀. (Relaxed).
32. *Isoperla transmarina* (Newman). Head of holotype ♀. (Dry).
33. *I. transmarina.* Abdomen of holotype ♀, from below. (Relaxed).
34. *Isoperla holochlora* (Klapálek). 8th and 9th sternites of lectotype ♀. (Dry).
35. *I. holochlora.* 8th sternite of cotype ♂. (Dry).
36. *Isoperla irregularis* (Klapálek). 8th sternite of lectotype ♀. (Dry).
37. *I. irregularis.* Lobe of 8th sternite of neo-allotype ♂. (Dry).
38. *Alloperla cydippe* (Newman). Abdomen of lectotype ♀, from below. (Relaxed).



RICKER—SPECIMENS OF AMERICAN PLECOPTERA
IN EUROPEAN COLLECTIONS



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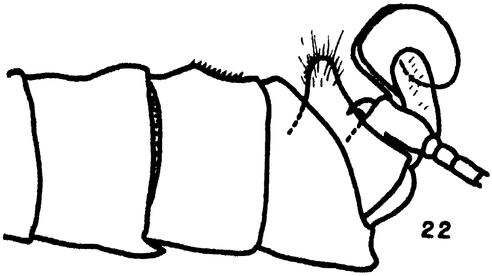

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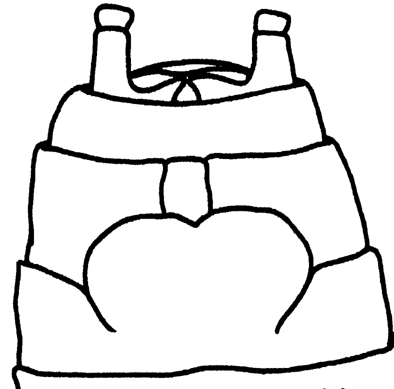

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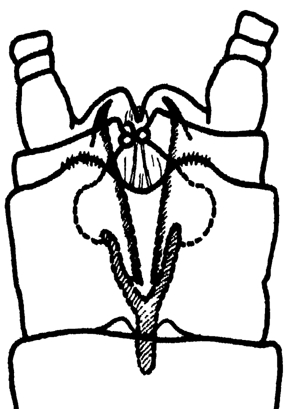

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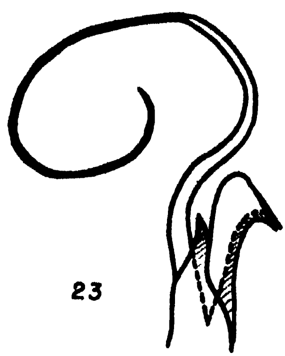

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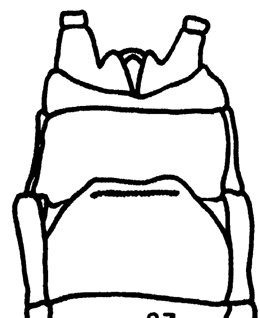

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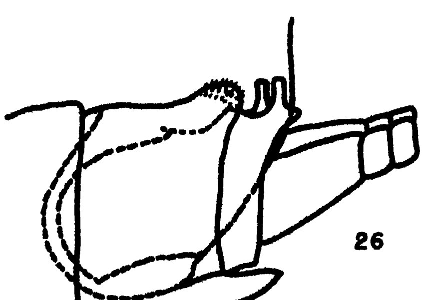

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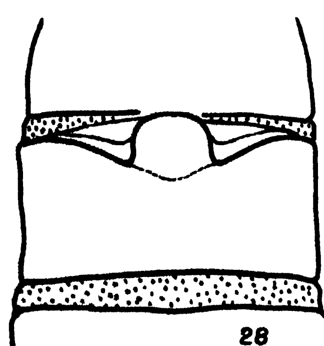

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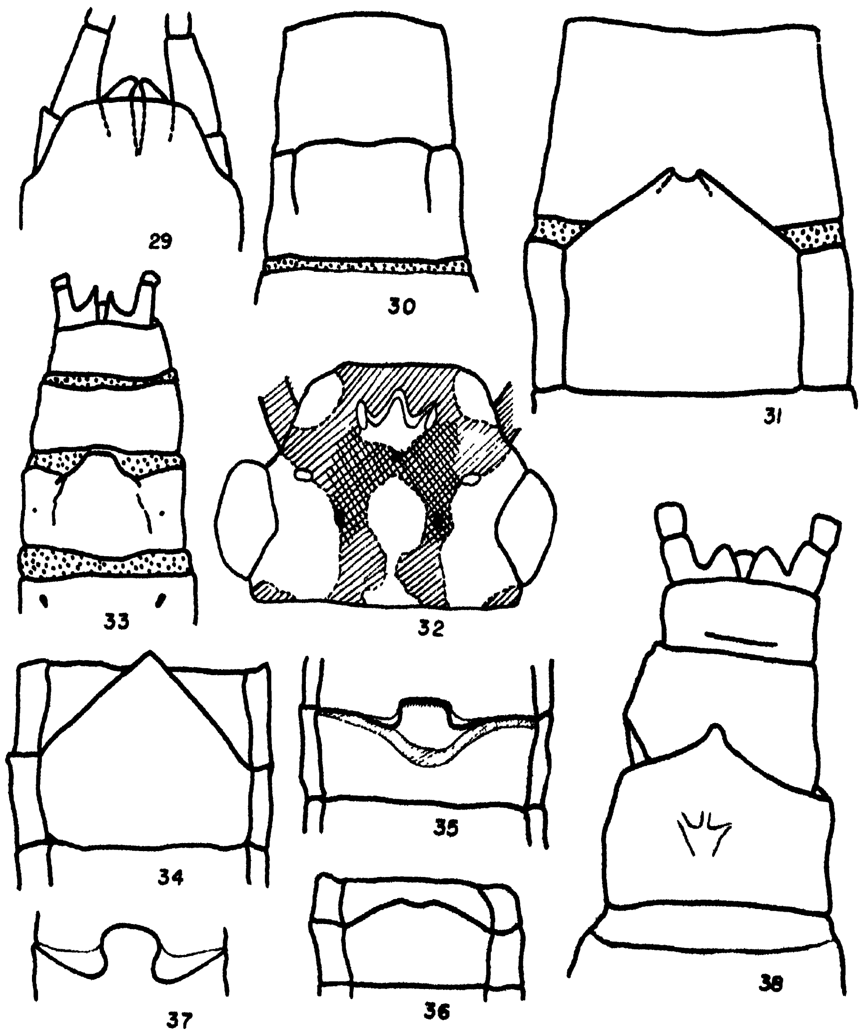
RICKER—SPECIMENS OF AMERICAN PLECOPTERA
IN EUROPEAN COLLECTIONS



RICKER—SPECIMENS OF AMERICAN PLECOPTERA
IN EUROPEAN COLLECTIONS

A FAUNAL INVESTIGATION OF WESTERN RAINY RIVER DISTRICT, ONTARIO*

By L. L. Snyder,
Royal Ontario Museum of Zoology

General Introduction

The papers which follow are a continuation of a series of reports based on collections and field studies made by the Royal Ontario Museum of Zoology in sections of the province from which specimens and other data were desirable. The field work for the present reports was accomplished between May 31 and August 10, 1929. The accompanying map circumscribes the area studied and on it the camps and collecting stations are indicated.

The portion of Rainy River District with which we are here concerned consists of approximately fourteen hundred square miles. It is bounded on the south by the Rainy River which constitutes the Minnesota-Ontario boundary; on the west by Lake of the Woods, which lies on the Manitoba-Ontario boundary; and on the east and north by Rainy Lake and the system of lesser lakes which mark the border of exposed pre-Cambrian rock in this region.

The underlying geological structure of the southern, central and western portion of this area consists of a schist complex essentially of volcanic origin (Map 266A, Dept. of Mines, Ottawa). These rocks, however, are largely covered by glacial drift and sediments. Coleman (1922) states that Lake Agassiz occupied parts of Saskatchewan, Manitoba and Ontario in Canada and parts of North Dakota and Minnesota in the United States. Lake Winnipeg in Manitoba, and Lake of the Woods and Rainy Lake in Ontario, are successors which occupy portions of this original basin. The physiography of the western portion of Rainy River District shows markedly the effects of glacial deposition and the levelling-off processes which were at work in the basin of Lake Agassiz.

Along the eastern and northern border of this area, granite and granite-gneisses, hard rocks of Archaean age, are exposed or lie near the surface. The irregular depressions on these are filled with water which spills from one to another thus constituting chains of clear lakes which find their drainage through Rainy River to Lake of the Woods and thence to Lake Winnipeg and to Hudson Bay via the Nelson River.

As a whole, the area with which we are concerned supports a

*Contribution No. 14 of the Royal Ontario Museum of Zoology. Publication assisted by the Reuben Wells Leonard Bequest.

considerable forest cover, although much arable land is under agricultural development, a point to be mentioned later. Lumbering, fires and clearing of the land has interrupted the forest cover here and there, especially in central and southern parts. Extensive "wild" plots of woodland and bog still exist along with cultivated lands and these areas are more or less linked to the continuous and primaeval hinterland.

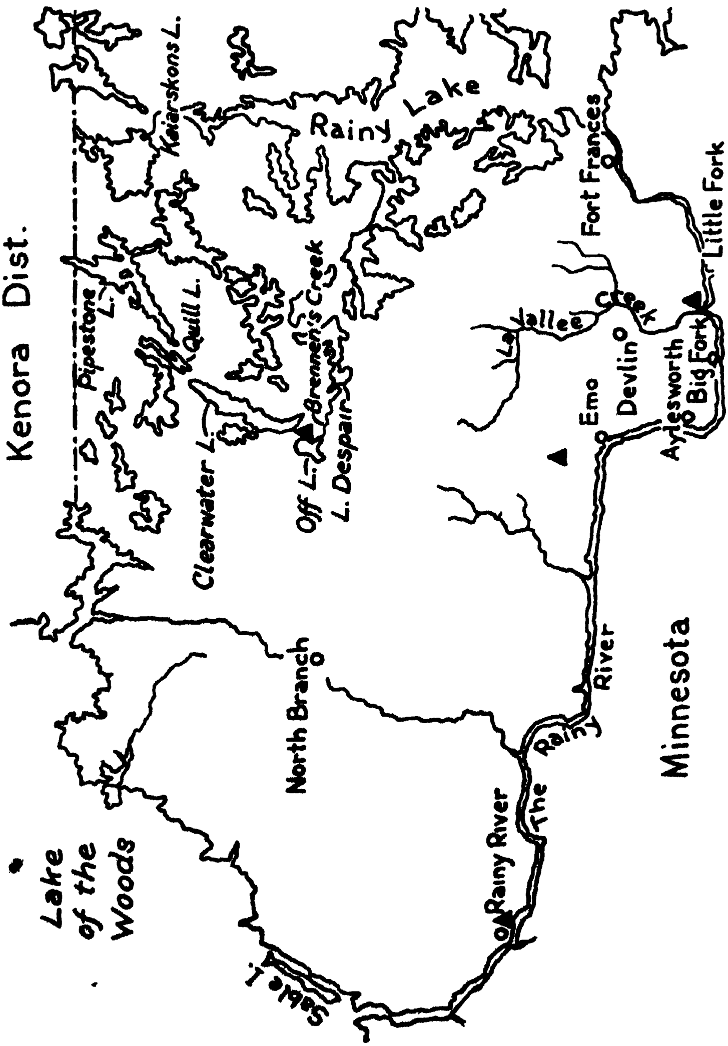
The earliest reference to the forests of the region appears to be that of Ballantyne (1848). In his account of a voyage by canoe from Lake of the Woods eastward on the Rainy River, made in September, 1841, he mentioned that "ash, poplar, cedar, red pine, white pine and birch" grew along the banks. The same trees would be identified on a similar journey to-day but continuous tree-growth does not now characterize this section of the district and pines have been largely cut out. In southern and central sections poorly drained areas still support stands of black spruce. Here and there aspen poplar woods predominate in the landscape. The heaviest stands of trees are to be found on Indian Reserves, of which there are several. On these one finds old stands of aspen poplar, balsam fir, balsam poplar, white spruce, black ash and American elm.

Creek bottoms are for the most part wooded with relic assortments and rather extensive woodlots and open wooded pastures are found on farms. Several species of trees of more than ordinary interest are not uncommonly met with. These are bur oak, box elder and hawthorns. Among the principal shrubs to be found are mountain maple, speckled alder, red-osier dogwood, beaked hazel, pin and choke cherry and species of *Salix*, *Viburnum* and *Amelanchier*.

The northern lake country which borders the area undergoing agricultural development, supports largely a mixed forest. Black spruce bogs and white cedar swamps characterize the lower ground. Lumbering has removed the larger white and red pines, although second growth of both species is to be found and jack pine occupies dry situations in extensive areas, especially to the north.

Sharpe and Brodie (1931) compare the forest of the Rainy River District with that of the Sudbury District in Ontario. Further, they state that the probabilities are that these two floras originated from the same centre following glaciation. Their description of the forest of Rainy River District will apply more particularly to the rough lake-country which constitutes the border of the area dealt with in this report.

It seems probable that the portion of the district bordering the Rainy River would yield a number of western and southern floral



Western Portion of Rainy River District, Ontario

▲ R.O.M.Z. Camps

elements not characteristic of the district as a whole, if it were investigated botanically.

Agriculture had its beginning along the Rainy River more than forty years ago. In 1890 only a few clearings had been made and these were located along the Rainy River which was the only highway for travel. In due course farms were established along a sixty mile front, from the town of Rainy River on the west to Fort Frances on the east. At the present time farms and roads extend inland for fifteen or twenty miles, especially in the central district north of the town of Emo. Small pioneer farms, made and occupied largely by immigrants from Finland, are found in the north bordering the lake country.

The clearing of extensive tracts of land in this region undoubtedly has had a considerable effect on the fauna now to be found there. The Ontario portion of the broad and flat basin of glacial Lake Agassiz, situated as it is close to native prairie (30 miles to Roseau, Minnesota), has become prairie in effect where the forest-cover has been removed. We were informed by residents of the district that in 1910 a great fire swept from the vicinity of Warren to Baudette, Minnesota. This tended to create a corridor which conceivably could have facilitated eastward extensions of range of prairie forms. Then too, railroad right-of-ways are important features in connection with recent dispersals.

The climate of the western portion of Rainy River District is one of considerable extremes because of its interior-continental location. The isotherm of 0°F. for January (like White River, Ont.) passes through the area, as does also the 67°F. average for July (like Toronto). Sharpe and Brodie (loc. cit.) give the frost-free period for the district as a whole as ninety-three days, which approximately corresponds to Parry Sound and Muskoka Districts in eastern Ontario. The annual precipitation is 23.74 inches, approximately half of which falls in the growing season.

PREVIOUS WORK IN THE REGION

So far as it is known no comprehensive studies or surveys have been made of the biota of the western portion of Rainy River District. A few papers dealing with the fauna of territories more or less adjacent to the area here considered may be mentioned. The earliest of these is on the birds of Itasca County, Minnesota, by Cahn (1920). A paper by Johnson (1920) deals with the summer birds of Lake County, Minnesota. This was followed by additions relative to the birds of Lake County by the same author (1921 and 1923) and by Cahn (1922). In 1921 Cahn published a paper on the mammals of Itasca County, Minnesota. Next in chronological order are two papers on birds from

Indian Bay, Lake of the Woods, Manitoba (and Ontario) by William Rowan (1922A and 1922B). In 1930 Johnson's paper dealing with mammals of northwestern Minnesota appeared. The next item is an illustrated descriptive account of the country "between Lake Superior and Lake of the Woods" by Jaques (1931). Another paper to be mentioned is that of Tanton (1935) which deals with a fresh water bryozoon found in the eastern part of Rainy River District.

The only published papers dealing with the fauna of the western portion of the Rainy River District, so far as the writer is aware, are those of Brimley (1929, a and b). These two papers deal with insects and were based on collections made there during 1924. A few specific records of animal occurrences in the region have been found in the literature. Where pertinent these will be cited in the following annotated lists.

LIFE ZONES AND FAUNAL AREA

The incidental gathering of data relative to the trees and shrubs occurring in the western part of Rainy River District was sufficient to show that the forest of the region is fairly typical of the eastern section of the Canadian life zone. The more complete record of vertebrate animals, which was the primary objective of our survey, demonstrates also that the composite association of forms in this region is largely characteristic of the Algonquin faunal area of the Canadian life zone. The peculiarities of this area, however, as compared with other sections of the province, regarded according to the life zone concept, were rather marked and require some mention.

In general the Rainy River fauna is similar to that of areas two to three degrees of latitude farther south, in southern Ontario. This is significant, since it indicates that the range limits of quite a number of vertebrate animals, particularly birds, swing northward in the west or toward the interior of the continent, thus paralleling summer isotherms. The following forms found in the Rainy River District substantiate this statement: Tree Toad (*Hyla versicolor*), Hooded Merganser (*Lophodytes cucullatus*), Cooper's Hawk (*Accipiter cooperi*), Piping Plover, (*Charadrius melodus*), Black Tern (*Chlidonias nigra*), Whip-poor-will (*Antrostomus vociferus*), Red-headed Woodpecker (*Melanerpes erythrocephalus*), Crested Flycatcher (*Myiarchus crinitus*), Eastern Wood Pewee (*Myiochanes virens*), American Rough-winged Swallow (*Stelgidopteryx ruficollis*), Purple Martin (*Progne subis*), White-breasted Nuthatch (*Sitta carolinensis*), Short-billed Marsh Wren (*Cistothorus stellaris*), Catbird (*Dumetella carolinensis*), Brown Thrasher (*Toxostoma rufum*), Wilson's Thrush (*Hylocichla fuscescens*), Common Shrike (*Lanius ludovicianus*), Baltimore

Oriole (*Icterus galbula*), Scarlet Tanager (*Piranga erythromelas*) and Grey Squirrel (*Sciurus carolinensis*). Additional species could be included as illustrating the above northward range penetration in the west but the cases cited are sufficiently numerous to illustrate the point. Also, it was found that many of the forms listed above were sufficiently numerous to suggest that their range extends northward beyond the western portion of Rainy River District in Ontario.

Some mention should be made of certain conditions observed which confuse the zonal picture in this region. The occurrence of low or poorly drained flats and troughs which support pure stands of black spruce (and an accompanying under cover of "oxylophytes") has been mentioned. These are ecologically similar to conditions prevailing in northern Canadian and Hudsonian zones. These "boreal islands" are especially common in the interior—Minnesota, Manitoba and adjacent parts of Ontario—and tend to confuse the zonal stratification in this region. Perhaps the most striking way to illustrate the point is to remark that the Red-headed Woodpecker was observed in a partial clearing near Big Fork while immediately opposite this situation in a black spruce forest an American Three-toed Woodpecker was collected. This might be interpreted as evidence of an overlapping of Carolinian and Hudsonian faunas, in terms of life zone representation.

In one other respect the western part of the Rainy River fauna is notably different from comparable faunal areas in the eastern part of Ontario. Because of the proximity to native prairie and because agricultural development has produced extensive tracts of treeless or pseudo-prairie conditions, a notable number of prairie forms has invaded the region. Some may have long since been established there. It seems probable that additional forms have since come to occupy the area. Some of these animals are certainly more characteristic of the Assiniboian faunal area. A significant assemblage of elements of this fauna has not previously been recorded for Ontario. The following species and subspecies comprise the more obviously western or prairie representatives in the Rainy River fauna: Northwest Swamp Tree Frog (*Pseudacris septentrionalis*), Mallard (*Anas platyrhynchos*), Green-winged Teal (*Nettion carolinense*), Poplar Sharp-tailed Grouse (*Pedioecetes phasianellus campisylvicola*), Western House Wren (*Troglodytes aedon parkmanni*), Western Palm Warbler (*Dendroica palmarum palmarum*), Western Meadowlark (*Sturnella neglecta*), Giant Red-wing (*Agelaius phoeniceus arctolegus*), Nevada Cowbird (*Molothrus ater artemisiae*), Prairie Savannah Sparrow (*Passerculus sandwichensis campestris?*), Western Vesper Sparrow (*Pooecetes gramineus confinis*), Clay-colored Sparrow (*Spizella pallida*), Dakota Song Sparrow (*Melospiza

melodia juddi) and Franklin's Ground Squirrel (*Citellus franklini*).

Although the emphasis has thus far been placed on the irregularities and peculiarities of the fauna of the western part of the Rainy River District, reference to the complete list of animals recorded in the papers which follow will show that animals usually regarded as characteristic of the Algonquin fauna of the Canadian zone predominate. There is no doubt that the fauna of Rainy River District is the richest and most varied of any area visited so far during the prosecution of the Museum's surveys.

CAMPS AND ITINERARY

Observations and collecting in the western portion of Rainy River District was started by Mr. H. P. Stovell and the writer at a camp a few miles north of Emo. Arriving on May 31, 1929, work was carried on here until June 30. From the camp at Emo collecting and observation trips were made to other points, along the Rainy River immediately to the south, southeast to Big Fork and eastward to Fort Frances. On June 30 we were joined by Messrs. J. L. Baillie, A. R. Van and Chas. Tompkins. Camp was removed to Off Lake from which trips were made to adjacent territory—Clearwater Lake, Quill Lake, Lake Despair, etc. Completing the work here on July 13, camp was removed to near the mouth of La Vallee Creek where Messrs. Baillie and Stovell worked until July 27. After this they removed camp to near the town of Rainy River, completing field work on August 10. From the last camp trips were made along the Rainy River and on to Lake of the Woods as far as Sable Island.

ACKNOWLEDGEMENTS

The major portion of the work in connection with a faunal survey is in the collecting and preparation of specimens. In the ornithological work, the writer had the experienced aid of Mr. James L. Baillie, Jr., of the Museum staff. Mr. H. P. Stovell, at that time a member of the staff, did the major portion of the mammal work. Their cooperation and valuable assistance in this undertaking is especially appreciated.

Mr. A. R. Van of Toronto was a member of the field party for a short period during July. Although he was primarily concerned with adventures in wild-life photography, he contributed much towards camp routine and discovery work in the field.

Local persons who rendered valuable assistance in the field are too numerous to be mentioned individually but Mr. Edgar Sullivan of Emo who was, and has since been, most helpful to the Museum deserves our thanks in print. Then there is Mr. Charles Tompkins, who was then

only a boy but very successfully conducted the culinary duties in camp at Off Lake. To the Thompson family, the Tompkins, the Sullivans, the Halls, Mr. Fisher (agent for the Provincial Agricultural Board), Messrs. C. R. and R. B. Langstaff, W. M. Oglestian, D. Mair, F. Corigan, A. Hanson, Ronald Nichols, Pat Byrns, and many others our thanks are due for various acts of hospitality and contributions to the survery work of 1929.

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THE MAMMALS OF WESTERN RAINY RIVER DISTRICT, ONTARIO

For the most part, the record of occurrence for the various forms of mammals tabulated in the following list is based on the Museum's collection made in 1929. A number of forms, however, particularly the fur-bearers and larger mammals, are included on evidence other than collected specimens.

In some of the taxonomic revisions of North American mammals the Ontario ranges of indigenous forms have been circumscribed on the basis of specimens examined, but even in the more recent literature the inadequacy of local collections from our province has left many details yet to be worked out. Inaccuracies of provisional conclusions become apparent as specimens from a wider field are secured, and a reinterpretation of the forms to be recognized and a restatement of the ranges they occupy in Ontario will eventually be necessary. It seems advisable here to allow final racial determinations to rest but in some cases differentiation is discussed briefly. For the purpose of this local list specific identity is sufficient.

In the following list, the linear measurements given for specimens collected are in millimetres, and the weight in grams. The total length is indicated by L., tail vertebrae by T., the hind foot by H.F. and the weight by Wt.

Condylura cristata. STAR-NOSED MOLE.—Mr. Douglas Mair, a farmer-naturalist near Emo, who was more especially familiar with animals in Scotland, informed us that he had caught, near Emo, a mole similar to the "old country mole" with a "sharp nose and big shovel fore-feet." There is considerable doubt as to what this might have been, but *Parascalops* or *Scalopus* are both possibilities. There is no doubt, however, about a second animal which Mr. Mair and other residents described. They told us of the capture of several moles which possessed "a fringe on the nose." Although we did not succeed in obtaining a specimen, Mair's record can be accepted as representing *Condylura* without doubt. The species has been recorded for south-eastern Manitoba (Miller, 1924) and Lake Nipigon, Ontario (Dymond, 1928).

Sorex cinereus. CINEREOUS SHREW.—Specimens of this shrew from Rainy River do not exhibit any significant difference in size or colour when compared with specimens from the province at large. Dr. Jackson has examined the series and refers them to the form *cinereus*. Specimen No. 29.9.9.333 was found to possess supernumerary

teeth (one on each side of the maxilla), which are situated between the fourth incisor and the canine.

Ten of the thirteen specimens preserved were secured in moist or wet situations well covered by plants, shrubs and trees but not a bog or muskeg association. Of the other three, two were taken in dry situations in a mixed forest and the third was secured on a high dry moss-covered rock in a balsam woods.

A female taken July 20th contained six embryos.

The average measurements of the thirteen specimens preserved are L. 96, T. 38, H.F. 11.5, Wt. 4.2.

Sorex arcticus. SADDLE-BACKED SHREW.—Although the Rainy River District falls within the border territory of *S. a. arcticus* and *S. a. laricorum* as outlined by Jackson (1928) our series of specimens has since been examined by Dr. Jackson who refers them to the race *arcticus*.

The tricolored pattern of this species is faintly apparent in all the specimens which are of course in summer coat. In comparing these specimens with representatives of *S. fumeus* and *S. cinereus* it has been noted that in addition to the cranial and size differences mentioned by Jackson, the upper surfaces of the feet of *S. arcticus* are distinctly more hairy than in either of the other species, a character which probably becomes more apparent in museum specimens, since the feet of both *S. cinereus* and *S. fumeus* are much paler when dry and therefore reveal their nakedness as compared with *S. arcticus*.

Like *S. cinereus*, this shrew was taken in moist situations in Rainy River District, usually bogs but there is some overlapping of habitat of the two species. Seven of the ten specimens preserved were definitely associated with bog or muskeg condition. The other three were secured in characteristic *cinereus* habitat, namely on moist or wet ground beneath alders etc.

The average measurements of the ten specimens are, L. 110., T. 41.5, H.F. 14, Wt. 7.

Microsorex hoyi. PIGMY SHREW.—Two specimens of this shrew were secured, one from beneath willows and black ash bordering a low section of the shore of Off Lake and the other from under birch saplings bordering a black spruce bog. A point of interest in connection with one specimen is that it was caught during the daytime.

The Rainy River area falls between the ranges of the two races *hoyi* and *intervectus*, according to Jackson's map (1928) but the two specimens have been since examined by Dr. Jackson, who refers them to the more northern form, *intervectus*.

The average measurements for the two specimens are L. 93.5, T. 33, H.F. 10.5, Wt. 4.

Blarina brevicauda. MOLE SHREW.—No opportunity was afforded to compare the Rainy River specimens of this species with adequate material from the Mississippi valley but no significant difference has been found when compared with specimens taken at various places in Ontario. The specimens have been examined by Dr. Jackson who accepts the form *talpoides* and so names the Rainy River material. Undoubtedly they are like specimens from the type locality of that form which is between Toronto and Lake Simcoe.

All of the specimens were secured in dry situations but where water, standing or running, had been present earlier in the year. Dense overgrowth characterized the immediate habitat where the specimens were secured, either poplar or mixed woods.

The average measurements of the five specimens, all of which appear to be fully adult, are, L. 116.5, T. 23.5, H.F. 15, Wt. 18.7.

Myotis lucifugus. LITTLE BROWN BAT.—During the second week of July at our camp at Off Lake small bats were seen on several evenings. Although three or four were shot, we were successful in recovering only one specimen. This proved to be a female of the Little Brown Bat, *Myotis lucifugus lucifugus*. The measurements of this specimen are as follows: L. 93, T. 39, H.F. 10, W.S. 259, height of tragus 6, Wt. 8.5.

Lepus americanus. VARYING HARE.—During the summer of our visit to western Rainy River District (1929) the Varying Hare was scarce and only two specimens were secured. A total of only nine individuals was observed during the entire summer. Residents informed us that the hare died off in the district between the winters of 1925-26 and 1927-28. The adult specimen secured was heavily infested with ticks about the head, and five cysts were found, four intermuscular on the hips and the hind limbs, and one attached to the intestine in the pelvic region.

Although the form *phaeonotus* has been attributed to this part of Ontario (Nelson, 1909), the material at hand does not confirm this. The general characters of this race were described as: "size of typical *americanus*, but in summer paler and more buffy". In comparing the one adult specimen from western Rainy River District with summer specimens from various northerly stations in Ontario, it might be said to differ from them in being darker and less buffy than the average. In size it is similar. The great individual variation of the American Hare in summer appears to make it impossible to classify the Rainy

River specimen racially. More material, taken in both winter and summer from this area is very desirable.

The measurements of the adult secured are: L. 430, T. 31, H.F. 132, Wt. (poor physical condition), 1345.

Lepus townsendii. WHITE-TAILED JACK RABBIT.—Residents of the town of Rainy River informed our party working there that enormous "Jack Rabbits" occurred in large numbers on Sable Island, ten miles north of the town, off the mouth of the Rainy River in Lake of the Woods. The island is composed of sandy soil, and though unforested, it has a considerable growth of low scrub. Messrs. Baillie and Stovell visited this area on Aug. 8 but did not see any of the animals. The lighthouse keeper there informed them that "wolves" visited the island the previous winter and thinned them out. Substantiating specimens from the area are particularly desirable, and would constitute the first from the province.

Marmota monax. WOODCHUCK.—Not uncommon in farming districts and fairly common in the bordering lake country to the north and east.

The skull of a young Woodchuck taken at Emo in October, 1931, and forwarded to the Museum by Edgar Sullivan is a notable example of abnormal incisor growth. The upper incisors have decurved in their growth until the tips have reached the roof of the mouth, in fact, one has entered the bony structure immediately forward of the first upper premolar. The lower incisors are approximately 40 millimetres long. They have grown in an arc which, in life, would have been not only distal to the upper incisor but external to the fleshy upper lips, terminating well above the nostrils. The middle distal face of the curved upper incisors occlude on the basal lingual surface of lower ones.

This animal was shot. It had managed to live on with a dental condition which prevented gnawing and which must have greatly interfered with mastication.

Comparison of the Rainy River skin specimens, which are in summer coat, with comparable material from southern Ontario, *M. m. rufescens* shows the former to be less reddish ventrally and the hair of this surface more grizzled. One specimen particularly is similar to an Iowa taken example of *M. m. monax* on the ventral surface but not at all like it dorsally. Compared with specimens from central and northern Ontario the Rainy River specimens are not as bright reddish ventrally and are darker dorsally. One, however, closely approaches a Groundhog from Lake Nipigon. Because of the lack of sufficient comparable adult

specimens from numerous sections of the province, it is not expedient here to refer the Rainy River Groundhogs to a particular race.

The measurements of the larger of the two specimens secured are: L. 558, T. 108, H.F. 76. The second specimen is apparently not mature, since it was non-breeding and measured L. 501, T. 102, H.F. 75, Wt. 2220.

Citellus franklini. FRANKLIN'S GROUND SQUIRREL.—Early in our stay at the camp near Emo we made enquiries of residents as to the occurrence of ground squirrels in the region. We were told that, although they did not occur in that vicinity (which is more or less central to the region surveyed), they did occur to the west near the town of Rainy River. A camp in that region was a part of the summer's programme. In due time the section was visited by Mr. Baillie and Mr. Stovell and a series of Franklin's Ground Squirrels was secured. These constitute the first to be taken in the Province of Ontario. A sight observation of this species was made at Rainy River station prior to our visit to the area, and has been recorded by Green (1932).

Apparently this animal is a fairly recent arrival in the district—certainly it was not present when the area was opened up for agriculture. Mr. Michael Byrns, a resident of Rainy River, first saw it in June, 1925. As further evidence of its recent arrival it can be said that it is rapidly spreading eastward over cultivated sections. It now occurs at Emo (1936), which indicates an advance of some twenty-five or thirty miles in seven years.

A comparison of the Rainy River specimens with summer specimens from southern Saskatchewan (Indian Head and Dundurn) and Alberta (Dried Meat Lake) discloses some slight differences which, with more material at hand, may prove significant. The general dorsal colour of adults from Ontario is more greenish brown than is noted on summer adults from Saskatchewan and Alberta prairie. This general dorsal colour is of course derived from the tawny olive bands on the hairs; the black bands and tips of the hair tend to increase the greenish effect and to darken the tone. The light bands on the Saskatchewan specimens are noticeably paler. Although immature specimens from both areas are more richly coloured than adults, the comparative differences as pointed out for adults prevail in this coat also. Material from southern Manitoba (Aweme) agrees more closely with the Ontario specimens.

The average measurements of three fully adult females from Rainy River are: L. 367, T. 127.5, H.F. 51, Wt. 452.

Eutamias minimus. WESTERN CHIPMUNK.—This chipmunk was seen regularly throughout the summer but it was not as common as the

next species. It occurred in both agricultural districts and the wilder lake country bordering that area.

There seems little doubt that some refinement of our plotting of racial distribution of *E. minimus* is necessary, especially in the northern and eastern portions of its range. Adult specimens from Rainy River approach very closely comparable specimens (assumed *E. m. borealis*) from central Alberta (Camrose, Edmonton, etc.), south-central Saskatchewan (Lake Katepwa, Craven and Prince Albert), and southern Manitoba (Aweme). They are, however, considerably darker than specimens from Qu'Appelle valley, Saskatchewan, which do not appear to be referable to *borealis*. Further, the Rainy River specimens differ from material taken at various stations eastward in Ontario in being somewhat less tawny and slightly paler on the crown. This appears to be more strikingly the case when comparisons are made with northern specimens (Lake Nipigon, Lake Abitibi and Smoky Falls).

The average measurements of four female specimens which are adult are as follows: L. 210, T. 94, H.F. 33.5, Wt. 54.

Tamias striatus. EASTERN CHIPMUNK.—Common, somewhat more so than the smaller species and generally distributed throughout the area. Geographically the Rainy River specimens should represent the form *griseus*, which they probably do but, because of lack of material, it has not been possible to establish typical *griseus* in the province by comparisons. Certain variations in the Eastern Chipmunk over the province have been noticed by Mr. E. C. Cross, who has made preliminary studies on this animal from the northeastern part of its range. His observations, with which the writer is acquainted, dictate that it is inopportune to do more than specifically record the so-called Eastern Chipmunk from Rainy River.

The average measurements of the adult specimens collected are as follows: L. (four specimens), 258.5, T. (four specimens) 102.5, H.F. (five specimens) 36, Wt. (five specimens) 102.

Sciurus hudsonicus. RED SQUIRREL.—Common and generally distributed during our visit to the region.

Dr. R. M. Anderson has examined the specimens of red squirrels from Rainy River in connection with a broad survey of this species in Canada. In his opinion, the specimens are referable to the northern form, *S. h. hudsonicus*.

It is of interest to note, however, that the average measurements of the series of adults are slightly larger than the average for adults from any other area in northern Ontario. This fact may signify an approach toward the large form, *S. h. minnesota*. Although seventeen specimens

were preserved, only eight were mature. The average measurements of these are: L. 307.5, T. 119.5, H.F. 47.5, Wt. 199.

Sciurus carolinensis. GREY SQUIRREL.—On June 2, a specimen of this species was secured from the border of a woodlot on the Thompson farm near Emo. This record was especially surprising to local residents, who had never before seen the grey squirrel in this section of the province.

The specimen, a female in new summer coat, appears not to be an old individual, though certainly it is not a young of the year during which it was collected. It was not pregnant nor had it suckled young that year. The incisors however are heavy, approximating specimens known to be fully adult, and the general body measurements correspond well with sexually mature specimens.

The grey phase of the Northern Grey Squirrel (*S. c. leucotis*) is so variable in colour that it is difficult to select typical or average specimens for comparison. Further, there appears to be a colour and pattern difference between adults and immature specimens, a description of which has not been found in the literature. In the material examined, the known young (grey phase) specimens from southern Ontario have the white pattern of the ventral surface very restricted, the yellowish brown of the lateral areas encroaching on the belly and meeting anteriorly and posteriorly. Also, the lips and chin are dusky black. This in effect describes the Rainy River specimen and also describes in part one of the alleged characters of a western race of the species, *S. c. hypophaeus*. Altogether, it seems impossible to classify, racially, the grey squirrel from Rainy River material at hand. It seems probable that the specimen secured originated from stock inhabiting northwestern Minnesota. The distribution of the species is not continuous eastward to southern Ontario, north of the Great Lakes. Further, the novelty of the occurrence of the grey squirrel in Rainy River District suggests a recent arrival.

The measurements of the specimen secured are: L. 468, T. 212, H.F. 66, Wt. 537.

Glaucomys sabrinus. NORTHERN FLYING SQUIRREL.—Although we were not fortunate enough to obtain a specimen of the Flying Squirrel during our summer visit to the Rainy River District, an adult specimen was later forwarded to the museum from there by Mr. Edgar Sullivan. Reports indicate that this species is not uncommon there at least during some years, and that they are most in evidence in the

northern and eastern lake country in the trapping seasons, at which time they are attracted to baited traps set for fur bearers.

The specimen in our collection, a male, is indistinguishable in colour and tone from comparable material from Ontario, north of Lake Superior. Also, the size and conformation of the skull is like specimens from that region. The measurements of the specimen are: L. 280, T. 125, H.F. 37. On the basis of these comparisons, the single specimen is referred to the form *sabrinus.*

Castor canadensis. BEAVER.—The beaver has disappeared from the settled portion of western Rainy River District. It is still taken by trappers in the border country but the trapper must go farther afield for beaver catch as time goes on. We saw no beaver during our stay in the region.

Peromyscus maniculatus. WHITE-FOOTED MOUSE.—This species was common and generally distributed during the year of our visit to Rainy River District. No striking habitat choice was noted, beyond the fact that they occur in or near woods; dry situations or moist situations, dense cover or open woods, second growth or old forest-stands, all yielded a portion of the catch.

Twenty-nine sexually mature specimens were preserved. About twenty-five per cent of these are obviously quite young. The remainder, vary in colour (as nearly as can be determined under the difficulties of hair-coat texture) from "wood brown" to "sayal brown" from their dorsal aspect. Darkening along the median line of the back is very slight. Immaturity does not account for the greyer specimens, judging by size, since the largest specimen in the series is of this type. It measured L. 190, T. 98, H.F. 22, Wt. 22. The range of variation as regards both size and colour of the Rainy River series embraces the range of characters ascribed to both of the forms *gracilis* and *maniculatus.*

After making comparisons with series from throughout northern and central Ontario and noting the general variability of colour, size and proportions of northern representatives of this species, the writer has been unable satisfactorily to segregate, geographically, the two races supposedly involved. If both forms are valid, it would appear that their ranges overlap through most of the central and northern parts of the province, Rainy River included. Perhaps typical *maniculatus* which was described from "Moravian Settlements of Labrador" and further designated as occurring in the "Hudsonian Zone" is restricted to the far north. A comparison of skull material does not alter the confusion pointed out in connection with skin comparison.

The average measurements of a number of fully mature specimens

from Rainy River are, L. (seventeen specimens) 178, T. (eighteen specimens) 86, H.F. (seventeen specimens) 20.5, Wt. (nineteen specimens) 22.

Synaptomys cooperi. COOPER'S LEMMING MOUSE.—Specimens of this mouse were taken rather regularly but not commonly during the summer of 1929. Damp situations with moss, showing holes and runways, yielded the majority of the individuals but it is apparent that typical bog conditions are not essential to the species.

A sub-adult female taken on July 11 contained five embryos. One young male was carrying pieces of grass in its mouth when collected on July 17, and another, also a young male, was carrying moss when collected on July 30.

The occurrence of this species at Rainy River is a considerable extension of its known range westward from Lake Superior region.

Comparison of the series of skull and skin specimens indicates that the form represented is probably *S. c. cooperi.* The series is, on the whole, slightly paler than a series from central Ontario.

Seven of the nine specimens in the collection may be classified as sexually mature but only three are fully adult in size. The average measurements of these are, L. 112.5, T. 18.5, H.F. 18, Wt. 23.2.

Clethrionomys gapperi. RED-BACKED MOUSE.—The Red-backed Mouse was very common during our visit to Rainy River and a satisfactory series of specimens was secured. Although this mouse inhabited the heavier woods, suitable situations are still to be found in cultivated sections.

During the mid-forenoon on June 22, the writer observed a Red-backed Mouse transporting some material into a hole in the crest of a low rotten stump. The animal was watched while it made seven return trips over a distance approximately thirty-five feet. It traversed this distance in approximately 8 to 10 seconds. The course of the mouse was almost exactly the same for each trip. In going to the hole, its cheeks bulged with some material, either food for storage or fibre for a nest. It used the top of two horizontal logs as a right-of-way for most of the way when going to the hole but on the outward foraging journey it utilized a six-foot crevice or split in the log as a tunnel. When in motion it was particularly noticeable that the tail was bowed upward in a jaunty manner. Brief observations of this species were made several times during daylight hours.

The series of specimens of this mouse present certain points of interest. In comparison with the typical form, *gapperi*, from southern Ontario, the Rainy River specimens are notably smaller and rather

markedly more silvery grey in general aspect of the ventral surface. Dorsally they are very similar to typical *gapperi*. The chestnut colour of the back is like that of the typical form in tone and also the lateral region of most specimens is slightly washed with buffy brown. It would appear that the Rainy River specimens approach the form *C. g. loringi*. Individual specimens from the series might be so called without hesitation.

This type of Red-backed Mouse with silver grey belly can be traced eastward through the Lake Superior region. To the northeast, at Lake Abitibi, however, it has been noted that this animal becomes pronouncedly washed with buffy yellow on the ventral surface. It appears possible that in the northeast the species may merge with the form described specifically as *E. ungava* Bailey (= *C. ungava*). Like many of the small mammals in Ontario further general revision is necessary.

The smallest female secured, which was pregnant, measured as follows: L. 134, T. 35, H.F. 18, Wt. 29. Four embryos, approximately half way through the gestation period, were noted. This specimen was taken on July 1. Other observations of numbers of embryos concerned more fully mature specimens. They were as follows: June 3, six embryos; July 2, five embryos; July 3, five embryos; July 4, eight embryos.

The average measurements of twenty-four adults are: L. 138.5, T. 36, H.F. 18, Wt. 30.8. The largest specimen, a pregnant female, was L. 153, T. 42, H.F. 18, Wt. 46.

Microtus pennsylvanicus. MEADOW MOUSE.—This mouse was taken commonly at all camps and on many trap lines. Although moist ground beneath alders and grassy treeless flats appeared to be favoured habitats, dry and wooded situations were occupied to a lesser extent, perhaps as marginal habitat during a period of great numbers. Many situations revealed a maze of runways of this mouse. It was while inspecting a runway beneath the side of a log in a brushy clearing that the writer witnessed a fierce combat between two of these mice. Two animals happened to meet in a runway at a point almost at my feet. They immediately clashed. Though the fight lasted but a few seconds, they rolled over and over on the ground and their squeaks seemed to testify the viciousness of the struggle.

Dissection of a female collected on June 27th disclosed seven fully-formed embryos.

It will be noted from the figures given below that the *Microtus* of this region averages rather small in most measurements. Many of the mature specimens tend in dorsal colour toward a yellow brown, peppered

of course with black hairs. The yellowish colour is particularly noticeable on the side of the nose and face. At least two specimens have a more reddish ground colour of the dorsal coat, tending toward cinnamon brown. Some specimens seem indistinguishable in colour from *Microtus pennsylvanicus* from southern Ontario.

Examination of the skulls shows that those of most mature specimens are ridged, some pronouncedly so. None of the adult skulls is much arched and they tend to be "flat-topped" in comparison with specimens from southern Ontario. Comparison of skulls of specimens of approximately equal gross size from Rainy River and southern Ontario shows that the skulls of Rainy River *Microtus* are relatively smaller.

Although most of the *Microtus* specimens from Rainy River are identifiable as *M. drummondi*, individual specimens suggest a close approach to *M. p. pennsylvanicus*. It is suggested that the Rainy River series of specimens indicates that *pennsylvanicus* and *drummondi* are conspecific.

One specimen secured was found to possess a curious dental pattern which is of interest. It is a young animal measuring, L. 140, T. 42, H.F. 20, Wt. 24. The second upper molar does not possess the posterior loop characteristic of the group to which it belongs within the subgenus *Microtus*. It shows a very similar pattern on this molar to that found in *Microtus chrotorrhinus*. Close inspection, however, discloses evidence that a loop might have developed with the growth and erosion of the molar. The other dental characteristics of this individual, however, are like those of *pennsylvanicus* or *drummondi*.

Of the forty-three specimens preserved, twenty-three can safely be regarded as adults. The average measurements of these are: L. 169, T. 43, H.F. 19, Wt. 43.9. The largest specimen a female, measured, L. 180, T. 56, H.F. 20, Wt. 52. The skull length of this individual, is 26.5 and the zygomatic breadth is 15.

Ondatra zibethica. MUSKRAT.—Although the Muskrat was observed by us a few times, it was not particularly numerous about any of our camps or trapping stations. It is generally regarded as not having been plentiful for many years: it is trapped regularly for fur throughout the region. Skull specimens only were secured by us.

Rattus norvegicus. HOUSE RAT.—The rat population of the Rainy River District is largely confined to the vicinity of habitations flanking the river to the south. In the central region near Emo it occurs about farms, penetrating several miles northward. We were informed by residents near Emo that rats were unknown in the region five years previous to our visit in 1929. The point of greatest interest

in connection with this animal is that the normal brown phase is (or was in 1929) outnumbered by representatives of a black phase. Our collection of ten specimens, secured without apparent selection, contains eight of the black phase, one normal brown and one brown-and-white. Recent reports from the region (1936) stated that "black rats" were still common there and that white ones occasionally occur.

Mus musculus. HOUSE MOUSE.—A common inhabitant of settled districts. No date of first occurrence was secured but this species found its way into the region at a considerably earlier period than did the house rat.

Zapus hudsonius. MEADOW JUMPING MOUSE.—This species was not common during the year of our visit to the region. The writer is unable to detect any significant colour, tone, or pattern differences between the specimens from Rainy River and examples of *Z. h. hudsonius.* Dr. R. M. Anderson, who has examined this material in connection with his studies, agrees with this determination. The average measurements of the three adults secured are: L. 205.5, T. 121.5, H.F. 29.5, Wt. 14.5.

Napaeozapus insignis. WOODLAND JUMPING MOUSE.—We were able to obtain only one specimen of this species during the summer's trapping. This specimen was secured in a rather unusual situation, namely a farmhouse. Comparison of the skin with material from Ontario generally, shows it to be similar to the jumping mouse from the north shore of Lake Superior. The measurements given below indicate that the specimen, a female, represents a large form: L. 236, T. 150, H.F. 32.

Erethizon dorsatum. PORCUPINE.—Seen occasionally and, according to reports of local residents, it is not uncommon in the region. Twice in June porcupines were observed in, or crossing, open fields. One was seen to make his way to a woods some three hundred yards distant. We were told by a local resident that porcupines sometimes raid chicken roosts, but we were not able to verify such behaviour. An albino specimen taken on Manitou Island, Rainy Lake, was captive in the Toronto Zoo. The measurements of a specimen collected are: L. 631, T. 160, H.F. 93, Wt. 4725.

Vulpes fulva. RED FOX.—Although we secured no first hand evidence of the occurrence of this species in the summer of 1929, trappers stated that it is one of the staple fur-bearers of the region. Apparently the 1929 period was not one of great abundance of the Red Fox.

Canis latrans. BRUSH WOLF.—A farmer (Mr. Wilson) near Emo informed us that he moved to the region in 1890, and early learned to

know the "coyote". At that time there were only a few small clearings along the Rainy River and there were no roads. "Coyotes" were the animals which gave him trouble in raising sheep, rather than timber wolves.

During our camp at Off Lake, we heard "wolves" which we assumed to be Brush Wolves. Judging by the information we secured in the field, these animals were not markedly numerous during the time of our visit. The last period of local abundance was in 1926 according to reports. A young female specimen taken near North Branch in Sifton Township on Oct. 20, 1930, the skull of which is in the R.O.M.Z. collection, measured 43½ inches in length and the tail 13¼ inches.

Canis lycaon. TIMBER WOLF.—This animal is generally considered to be scarce in the Rainy River region. We were told that the Timber Wolf was more common to the south, in Minnesota. Mr. Albert Hanson informed us that these animals mate in February. He dug out a den containing four pups only a few days old on Apr. 27, 1929. Other dens he has seen have contained from two to eight pups. Dens are usually located on ridges of sandy soil.

Procyon lotor. RACCOON.—Residents who have lived in the district for many years reported that on two or three occasions, Raccoons have been trapped. All agree that it is a rare animal in this region.

Ursus americanus. BLACK AND CINNAMON BEAR.—Several residents informed us that the cinnamon variety of the Black Bear occurs occasionally in the region. A partial pelt of a cinnamon Bear shot September 24, 1936 at Hut Lake, Rainy River District, was recently presented to the Museum by Dr. H. M. Bowen. Although the locality is somewhat removed from the area with which we are here concerned, the specimen fortifies the general statement made above and incidentally, it apparently represents the first preserved material evidence that this colour variety occurs within the province. Trappers state that Black Bears are common in the region during certain years. We saw signs of these animals during the summer of 1929 and they were reported to be common that year.

Martes americana. MARTEN.—Mr. Albert Hanson, who traps in the Lake Despair region, secures Marten fairly regularly on his trap-line. Marten are not to be expected in the vicinity of settlements but occur in the hinterland to the north.

Martes pennanti. FISHER.—This is another important but none too plentiful fur-bearer of the region. Its occurrence is to be expected only in the wilder parts.

Mustela cicognanii. BONAPARTE WEASEL.—The number of weasels taken by trappers in the region varies from one period to another. We secured only skull specimens. A desiccated carcass of a weasel in winter coat, found during the summer, was measured but could not be sexed. Applying the questionable determination index of tail length and the relative amount of terminal black hair on the tail, this animal was regarded as representing the short-tailed form, *M. c. cicognanii* Bonaparte.

Mustela vison. MINK.—A regularly taken fur-bearer of the region, according to trappers. It was apparently not numerous during the summer of 1929, since we did not meet with it in any section visited. Reports indicated that 1927 was the last year of plentiful numbers.

Gulo luscus. WOLVERINE.—The inclusion of this animal in the list is based entirely on historic grounds, since trappers do not now secure or find trace of this animal. One resident recalled to us the capture of a specimen, apparently many years ago.

Lutra canadensis. OTTER.—This animal is regarded as very scarce in the region here concerned, but it occurs occasionally.

Mephitis mephitis. SKUNK.—A generally distributed and, periodically, a common mammal of the region. We secured three specimens during the summer of 1929. One had lost the terminal portion of its tail, but the other two are complete for study. The dorsal stripes on one of the specimens is quite narrow and discontinuous posteriorly. The other two are marked with pronounced and continuous dorsal stripes. In comparing these specimens with skunks from eastern and southern Ontario, the tails are noticeably thicker, with the broad ends black to the tip (in the two undamaged specimens). These characters, combined with the large size of the specimens, fulfil the characters of the plains race, *M. m. hudsonica.* The measurements of the undamaged male specimen are: L. 650, T. 215, H.F. 76, and those for the female are: L. 603, T. 205, H.F. 73.

Taxidea taxus. BADGER.—Mr. R. G. Dungey and Mr. D. R. Wilson informed us that a Badger was taken north of Emo in Carpenter Township a few years prior to our visit. Both of these men had seen the animal when captured, and they recalled that the pelt was marketed as fur by the trapper, netting him only sixty cents, since it was not prime. Mr. Dungey was very familiar with badgers, having lived on the prairie for six years, where he had shot many of them.

A second animal was trapped by Mr. Albert Kartino at "Crow Lake" [Kakagi] on the border of the general region here concerned in the early

fall of 1926, and a third specimen was taken at the same place in the early fall of 1927. We could not ascertain that the species had been long established in the region, though this is entirely possible. It seems likely that conditions in the western portion of Rainy River District are now more inviting to this prairie dweller than they would have been in earlier times.

Lynx canadensis. CANADA LYNX.—We were informed that this species is never numerous in the region but that it is taken sporadically in the wilder hinterland by trappers.

Lynx rufus. BOBCAT.—Mr. Douglas Mair, a local resident who is greatly interested in natural history, informed us that in the early winter of 1928, he trapped a peculiar cat, a description of which is here extracted from my notes made as he described the animal: "It was small, dapple spotted below, grey above, hair-pencilled ears, tail about nine or ten inches long with black rings about it." There would appear to be little doubt as to the identity of the animal from this description.

Odocoileus virginianus. WHITE-TAILED DEER.—This Deer was seen by us fairly regularly during the summer of 1929 and, curiously enough, it was met with more often in the cultivated sections visited than in the wilder lake country to the north. Farm fences are certainly not an impediment to their movements. A number of skulls and antlers of specimens about farms and camps were examined in an attempt to discover evidence of the occurrence of the so-called "Jumping Deer", *Odocoileus virgultus* (Hallock) which is generally recognized from Minnesota and Manitoba and which may appear in this section of Ontario. We were not successful in establishing a record and we did not meet with any one who recognized two deer in this region, but this does not close the question.

The white-tailed deer was first seen in the Rainy River country by Mr. Fisher, a resident there since 1890, in 1897. Other residents gave the same, or approximately the same, date for the arrival of this animal. It is said that they came in from Minnesota, after the land was partially cleared in the Rainy River District.

Alces americana. MOOSE.—Common in the region as a whole, and observed by us in both the settled and wilder sections. Residents told us that moose found in the settled southern Rainy River District were animals that had crossed the river from Minnesota. This seems entirely probable, since extensive wilderness areas are close at hand on the Minnesota side. The horn growth of a bull observed on June 11 had attained about one foot in length. Mr. Fisher informed us that the moose was present in the region when he moved there in 1890.

Rangifer caribou. WOODLAND CARIBOU.—The last caribou to be seen in the southern part of the region here considered according to Mr. J. Thompson Sr., a local resident, was in 1894. A more recent record was reported by Mr. R. G. Dungey, who stated that one was shot by Mr. W. R. Cooper about 1911 northeast of Emo on the town line, between Carpenter and Burriss townships. Mr. P. G. Byrns reported that the last to be seen at the south end of Lake of the Woods, in Spohn Township, was in 1916. The species is now scarcely to be expected in the region here considered.

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THE SUMMER BIRDS OF WESTERN RAINY RIVER DISTRICT, ONTARIO

The following annotated list is based largely on a collection of 325 skins (and a few other specimens) representing 107 species and the field notes made during June, July and early August of 1929. The richness of the summer avifauna of this region is revealed by the total of 138 species here treated, out of which less than ten would not be expected to breed in the region, at least occasionally. Most of the species included in the list are based on specimens collected but some are admitted on sight records or other evidence deemed satisfactory. The text in each case will indicate the basis for inclusion.

It has been evident as this collection was studied that it was not feasible to give more than a tentative opinion as to the racial identity of several forms occupying the region. Specimens from all over the province and contiguous areas, to say nothing of topotypic material are often essential and lacking for comparisons. It seemed best in making this report, to regard it primarily as a contribution to our knowledge of the distribution of species in the province and to consider the collection as another stepping-stone toward a more complete basis for eventual study of racial variation in northeastern North America. It has been fitting therefore to use specific nomenclature. In this we have followed Mr. P. A. Taverner ("Birds of Canada") who had provided a useful, and apparently the only available, system of species names in English. The systematic order is that of the 1931 edition of the A.O.U. Check-list of North American Birds.

Gavia immer. COMMON LOON.—The Loon was observed regularly during our work in the lake country from our Off Lake camp. Several attempts were made to secure specimens from this region for racial study but without success. It was discovered that the curiosity of these birds can be excited by an observer, himself concealed, waving a handkerchief tied on a stick. Although loons were thus brought approximately within collecting range, either they were too cautious to come sufficiently close, or the collector, under stress of the occasion, misjudged the distance and the birds escaped. Loons were noted rarely at other camps. A pair flew over the farmland at Emo on June 3, three were seen on a small bog lake near camp at Big Fork and one observation of the species was made on Lake of the Woods from our Rainy River camp. We secured no breeding evidence but local observers informed us that they nest on several of the lakes in the region and Macoun (1900) recorded a Loon's nest from Crow [Kakagi] Lake which is just beyond the northern border of the area considered in our survey.

Colymbus grisegena. RED-NECKED GREBE.—Although we did not observe this species during the summer of 1929, a breeding record from Lake of the Woods has been published by Baillie and Harrington (1936). This record concerns a set of four eggs taken June 4, 1904 and now in the Museum's collection. The species is therefore, hypothetically, a bird of western Rainy River region.

Podilymbus podiceps. PIED-BILLED GREBE.—The Pied-billed Grebe was not certainly identified until well on in the summer when Mr. Baillie found it on La Vallee Creek. Suitable waters for this species, in the sections we were able to visit, were relatively few.

Phalacrocorax auritus. DOUBLE-CRESTED CORMORANT.—This species was not met with until August 8, when Mr. Baillie visited Sable Island in Lake of the Woods, off the mouth of Rainy River. Four birds were noted about fishermen's pound nets off shore and six carcasses of dead birds, probably caught and discarded by the fishermen, were found to have drifted ashore. Lewis (1929) lists two references which establish the fact that this species breeds on Lake of the Woods.

Ardea herodias. GREAT BLUE HERON.—From one to four individuals were seen daily during our stay at Off Lake camp. The species was also noted near camp at Rainy River but not regularly. Several local residents of Emo told us of a nesting colony on an island in Kaiarskons Lake: eight or ten occupied nests were found there, on May 27, 1929, in standing dead trees.

Botaurus lentiginosus. AMERICAN BITTERN.—Rarely met with and then only near our Emo and Rainy River camps. Mr. Douglas Mair told us of having found a nest of this species near Emo during the early summer of 1928.

Anas platyrhynchos. MALLARD DUCK.—A few Mallards were found inhabiting the grassy margins of Brennen's Creek and the quiet bay at its mouth on Off Lake in July. It undoubtedly bred in this vicinity since a flightless juvenile was secured there. The species was also found on a small lake near Big Fork and noted from camp near the mouth of La Vallee River.

Juv. (incomplete), July 4, Off Lake. 2 Imm. ♀♀ July 21, Big Fork.

Nettion carolinense. GREEN-WINGED TEAL.—Mr. Baillie first discovered this species on July 19 on the Canadian side of the Rainy River opposite the mouth of Little Fork River. On the following day he was successful in securing a specimen which proved its breeding status locally. The two young birds secured represent two transitional

stages betweed the downy and first winter plumages. This is one of the few established records of the breeding of this teal in Ontario and the first proved by specimen evidence. However, the summer's observations indicated that this species is a comparatively scarce summer duck of the region.

♀ July 19, Big Fork. 2 Juv. ♀ ♀ July 20, Big Fork.

Querquedula discors. BLUE-WINGED TEAL.—On July 23, at Big Fork, Mr. Baillie saw a small duck with a brood of six or seven young which were too far away to be positively identified but his opinion was that they were Blue-winged Teal. Since the species is known to occur sparingly in contiguous areas (Baillie and Harrington, 1936-1937), it is included here hypothetically.

Glaucionetta clangula. COMMON GOLDEN-EYE.—This duck was noted only about the lakes of the border country north of cultivation. Although it was not particularly plentiful it was noted fairly regularly. Broods of downy young with parent females were noted repeatedly at Off Lake from July 3 to the end of our stay there.

Juv. ♂ July 11, Off Lake.

Lophodytes cucullatus. HOODED MERGANSER.—Met with only once during the summer, at Off Lake, July 3. A half-grown flightless young secured, substantiates the breeding status of the species. A second specimen collected on July 3, a young male entering its second year, is in the first winter plumage.

Juv. ♂ July 3, Off Lake. Imm. ♂ July 3, Off Lake.

Cathartes aura. TURKEY VULTURE.—About the middle of July, 1929, a specimen of this species was taken alive on the shores of Rainy Lake. Mr. Ronald Nichols, a local resident who saw the bird which was held captive for some time, described it unmistakably to Mr. Baillie. The occurrence of this species in contiguous area (Lake of the Woods), is of special significance in recording the species for Rainy River (Baillie and Harrington, 1936).

Accipiter striatus. SHARP-SHINNED HAWK.—An uncommon summer resident in 1929 but observed near camp north of Emo and near Big Fork to the southeast.

Accipiter cooperi. COOPER'S HAWK.—Somewhat more common than the last species; observed near Emo, at Off Lake and at Rainy River. Although the young specimen collected is a fully developed bird out of the nest and was taken on August 5, all facts relative to it suggest that it was reared locally. Apparently the same individual

had been seen, in the immediate vicinity where it was collected, previously and also an adult was located there.

On July 11, during mid-forenoon, near our Off Lake camp, the writer was attracted by the alarm notes of several species of small birds including Least Flycatchers, Red-eyed Vireos, a Kingbird and a White-throated Sparrow. A Cooper's Hawk was then discovered under the bushy top of a fallen tree near at hand. Though watched for a moment or so it was not aware of my presence. By an occasional awkward jump the bird appeared to be reconnoitering the ground in search of prey. Subsequent stomach analysis showed that it had recently fed on a Hermit Thrush but its behaviour certainly indicated that a young bird discovered on the ground would also have been added to its fare. This method of hunting, if such was the case, is not, of course, usual.

♂ July 11, Off Lake. Imm. ♀ Aug. 5, Rainy River.

Buteo borealis. RED-TAILED HAWK.—A pair of these hawks was established near our camp north of Emo and one, or both were noted almost daily. The species was seen occasionally during our stay at Off Lake and near camp at Rainy River. The one immature specimen secured on July 31, is a young of the year in a fresh plumage without adhering down. In all probability it represents a locally reared bird. The date of collecting is several weeks in advance of the time when the first southward movement of red-tails would be expected in this region. The specimen exhibits a slightly more extensive amount of terminal white on the inner webs of the wing coverts and scapulars than does the average juvenile red-tail from eastern Ontario in the Royal Ontario Museum of Zoology collection. The tail has nine rather narrow exposed transverse bars and is considerably suffused with rusty red. The "flags" are but slightly marked. The bird appears most properly regarded as representing the eastern form *borealis.*

A nest found near Devlin on April 10, 1925, by Alfred Levridge has been reported to us.

Imm. ♀ July 31, Rainy River.

Buteo platypterus. BROAD-WINGED HAWK.—Next to the Marsh Hawk this species was the most common and regularly observed hawk of the region. It was noted at all camps and a nest was found on June 14 near Emo above which an adult bird circled anxiously. Alfred Levridge of Devlin reports that he has found the species breeding in his locality.

♂ June 13, Emo.

Haliaeetus leucocephalus. BALD EAGLE.—Although residents told us that "eagles" had been seen in the region in summer there was

little certainty as to the species concerned. We did not note this eagle during 1929. However, the species is included here, hypothetically, on the basis of a non-summer record reported by B. W. Cartwright in his regular newspaper article in the "Winnipeg Tribune." He states that, "An adult Bald Eagle taken about March 6 (1932) at Emo, Ontario has been sent into the Western Taxidermists for preservation."

[Since writing the above Mr. Edgar Sullivan has informed me of a nest with young which he found on the shore of Clearwater Lake in 1935.]

Circus hudsonius. MARSH HAWK.—A common hawk observed regularly in the farmland region about Emo. As many as eight were seen on one day, June 25, but this was after young were on the wing. The first young of the year were noted on June 21. We did not note the species during our stay in the lake country, but it was recorded regularly again at our camps at Big Fork and at Rainy River.

Pandion haliaetus. OSPREY.—As might be expected this species was not encountered until we visited the lake country. A pair was established somewhere in the vicinity of Off Lake or Clearwater Lake and we saw or heard one or both birds fairly regularly.

Falco sparverius. AMERICAN SPARROW HAWK.—Observed at all camps, not commonly but regularly. An occupied nesting hole was found near Emo but no opportunity for further examination was afforded. Alfred Levridge of Devlin informs us that he has found this species nesting locally.

♀ June 10, Emo. ♀ Aug. 5, Rainy River.

Canachites canadensis. SPRUCE GROUSE.—Although we did not observe this species in 1929 it is known to local hunters and trappers. Apparently it is never common, though its numbers vary from time to time. Among our miscellaneous records of birds at the Museum from correspondence and questionnaires there is a specific record of the Spruce Grouse seen north of Barwick in 1927 by Gustav Both.

Bonasa umbellus. RUFFED GROUSE.—According to reports the last period during which grouse died off in the western Rainy River District was 1924. There had been a fair replacement by the summer of 1929 when we visited the area though grouse were not at all common. Fairly large family groups were seen during July. Males were heard drumming until near the end of June.

One day the writer stalked a male grouse which was stationed on a mossy stump in heavy woods. An approach was made to within

fifteen feet of the bird by moving cautiously forward only when it drummed. Apart from the fascination in the performance as such, two impressions were gathered. First, that the sound produced by the drumming bird did not become distinctly louder as one approached more closely. It was easier to estimate the direction of the bird than it was the distance to it. Second, it appeared that the bird was somewhat oblivious to my approach during the brief period of drumming. It would seem that the drumming habit would be a great aid to certain predators (a Goshawk for example) if they were capable of making use of it.

2 ♂♂	June 14, Emo.	♀	July 18, Big Fork.
Juv. ♀	July 4, Off Lake.	Juv. ♀	July 18, Big Fork.
♀	July 10, Off Lake.		

Pedioecetes phasianellus. SHARP-TAILED GROUSE.—Mr. Wilson, a farmer near Emo, settled in that area in 1890 at which time there were only a few small clearings along the river. He informed us that Sharp-tailed Grouse (known locally as the prairie chicken) were generally more common then than now. There were no roads or railways at that time.

During the period of our visit to the region this species was far from plentiful. It was seen on two occasions, once near Emo and once at Aylesworth. Much open country and muskeg was reconnoitered in search of this species but it was found only adjacent to farmlands where scattered trees, clumps and thickets of saplings and shrubs, fallen trunks and brush, broke an otherwise open landscape. Subsequent inquiry reveals that this species reached a point of large numbers during the period of 1932-34. Dying off occurred in 1934-35.

A young bird collected has a wing measurement of 86 mm. and was capable of at least a 50 yard flight. A partial set of eggs (5), collected on June 9, 1929, near Emo, by Douglas Mair, is in the Museum's collection.

The Sharp-tailed Grouse of this region represent the characteristic "brown" type of bird for which the name *campisylvicola* has been proposed (Snyder, 1935).

Juv. ♀	June 24, Emo.	Juv. ♂	June 24, Emo.
♀	June 24, Emo.		

Porzana carolina. SORA RAIL.—This rail was noted fairly regularly while we were stationed at Off Lake. Mr. A. R. Van, who was with the Museum party during this period of the summer, was able to obtain a moving picture of the Sora while it was constructing its nest. The species was also found breeding near Emo. On June 21, a Sora was flushed from her nest (containing eight eggs) situated in a

small clump of cat-tails in a wet muskeg area. The bird instantaneously dived beneath the water and disappeared. A visit to the nest made after the lapse of twenty minutes or so, caused the bird to flush again but this time the rail flew from the nest for a distance of about three feet after which it skulked for cover.

♀ June 21, Emo.

Charadrius melodus. PIPING PLOVER.—Two female specimens were collected out of a total of six observed by Mr. Baillie on August 8, at Sable Island. These are obviously young of the year. Although the type of shore on Sable Island seemed suitable for the nesting of this species no proof of their having done so there is available. There are records of the breeding of this species on Lake Winnipeg (Rogers, 1937) and it is possible that these individuals are transients from that area.

2 Imm. ♀ ♀ Aug. 8, Sable Island.

Charadrius semipalmatus. SEMIPALMATED PLOVER.—Although this species is transient in the region here concerned, its occurrence in summer entitles it to inclusion here. Mr. Baillie saw five individuals on Sable Island, Lake of the Woods, on August 8.

Oxyechus vociferus. KILLDEER PLOVER.—A common breeding bird of the cultivated section of western Rainy River District. This species is undoubtedly more common now than it was prior to settlement because of the tremendous expansion of terrain suited to the species. We did not note the species while stationed at Off Lake where more unchanged conditions exist.

Juv. ♀ June 15, Emo.

Capella delicata. WILSON'S SNIPE.—This species was found to inhabit uncultivated spots in low, wet meadows and tilled fields. It was not common; three were the most seen in one day. A pair, established near our camp north of Emo, was observed regularly. On June 4, one of these birds was seen perched on the top of a fence post uttering its soft, slightly descending "kuck-kuck-kuck." Overhead another bird circled about producing, periodically, the pleasing vibrant sound which is slightly ascending in tone and accelerated in speed. It occurs to the writer that the frequent reference to this note, in North American bird literature, as a "bleating" sound is most inapt. It seems probable that this term has been copied from the European literature where it may be descriptive of the sound produced by a species there.

Actitis macularia. SPOTTED SANDPIPER.—A fairly common breeding species along the Rainy River, its tributaries and the lake

shores of more northerly sections. A set of four eggs collected near Aylesworth was situated a few feet from the bank of a small creek in a wooded pasture. The male bird was found to be incubating, the time being 3:00 P.M.

♂ June 25, Aylesworth. ♂ Aug. 1, Rainy River.

Tringa solitaria. SOLITARY SANDPIPER.—This species was not met with during the summer until July 24, when a female was collected at Big Fork. So far as the evidence goes this bird was probably a transient. It is typical of the form *T. s. solitaria.*

♀ July 24, Big Fork.

Totanus flavipes. LESSER YELLOW-LEGS.—Mr. Baillie found this species very common at Sable Island on August 8. It is a summer bird in the region here considered, though undoubtedly a transient.

Imm. ♀ Aug. 8, Sable Island.

Pisobia melanotos. PECTORAL SANDPIPER.—Five migrant Pectoral Sandpipers were observed on Sable Island on August 8. The specimen collected is an adult in worn breeding plumage showing no signs of replacement.

♂ Aug. 8, Sable Island.

Pisobia minutilla. LEAST SANDPIPER.—The species was found to be a common migrant at Sable Island on August 8.

Imm. ? Aug. 8, Sable Island.

Ereunetes pusillus. SEMIPALMATED SANDPIPER.—The visit made to Sable Island on August 8, established this species as a common migrant there at that time.

Imm. ♀ Aug. 8, Sable Island.

Crocethia alba. SANDERLING.—Three migrant Sanderlings were noted on Sable Island on August 8. The specimen collected is an adult in worn breeding plumage.

♀ Aug. 8, Sable Island.

Larus argentatus. HERRING GULL.—A fairly plentiful species about some of the larger lakes of the region. Herring Gulls were observed reconnoitering the Rainy River from various points. The species nests on a bare rock island in Kaiarskons Lake and there may be breeding colonies on Lake of the Woods within the territorial scope of the area here reported on.

The single specimen secured is an adult female. From an examination of the ovaries it appeared that this individual was a breeding bird. The beak measures 53 mm. in length and is unmarked with black. The tail is entirely white, the primaries are white-tipped but only the first is marked by a mirror which is confined to the inner web and well separated from the apical spot.

♀ July 2, Off Lake.

Sterna hirundo. COMMON TERN.—This species was not met with until July 29 after camp was established at Rainy River. It was noted regularly and commonly at this station. Roberts (1932) states that breeding colonies are to be found on Lake of the Woods.

♀ July 29, Rainy River.

Hydroprogne caspia. CASPIAN TERN.—A Caspian Tern was seen by Mr. Baillie on August 8 on Lake of the Woods. Aside from this record we secured no information on its status in the region. Roberts (1932) states that eight or ten were observed on Lake of the Woods in July, 1916.

Chlidonias nigra. BLACK TERN.—This tern was observed regularly and commonly by us while we were encamped at Off Lake and also at Rainy River. Although we did not locate a breeding colony the daily foraging of adults suggested that one, or more, existed somewhere along the marshy borders of rivers, near Off Lake and also the Rainy River. At the latter place, on August 1, Mr. Baillie saw several young birds, accompanied by adults. The young possessed short tails, a state of immaturity which suggests that they were not far from the place of their nativity.

♂ Aug. 1, Rainy River.

Zenaidura macroura. MOURNING DOVE.—During our stay in the Emo district we were told by several local residents that a pair of doves spent the summer of 1928 in the vicinity of the canning factory at the edge of the village. Mr. Douglas Mair described their call and referred to them as Mourning Doves. Although the species is probably not established as a regularly breeding bird as yet there is evidence that it is penetrating into the province in this region and beyond, as an occasional summer resident. The evidence at hand suggests that the eastern form *carolinensis* is to be expected here.

Coccyzus erythropthalmus. BLACK-BILLED CUCKOO.—The status of this species in western Rainy River region probably varies from year to year since the limits of range are here approached. One noted on June 20 is our only record for the summer of 1929.

Otus asio. AMERICAN SCREECH OWL.—Mr. Hall of Emo described to us a small owl with ear-tufts which he has seen locally but rarely. Although we did not meet with the species in 1929 there seems no reason to doubt its occurrence. Thompson (1890) gives an early Ontario record on Lake of the Woods, specifically as Sabaskong Bay which bounds the area here considered. Specimens from this region would be of particular interest for racial study.

Roberts (1932) states that "some individuals from the north-western part of the state (Minnesota) are paler in colour and are regarded as Aiken's Screech Owl (*O. a. aikeni*)". A specimen in the R.O.M.Z. collection from Treesbank, south-western Manitoba seems clearly referable to this pale western race.

Bubo virginianus. GREAT HORNED OWL.—Heard fairly regularly throughout the summer but not commonly; seen rarely. We were not successful in securing summer specimens for study. Birds seen were pale in general effect, not of the *virginianus* type. Mr. Alfred Levridge of Devlin told us of having found the nest containing two very young Horned Owls on April 10, 1929.

Asio flammeus. SHORT-EARED OWL.—Not uncommon about the more prairie-like clearings of western Rainy River District. Near Emo, on June 24, a family of four variously-sized young was discovered in rough grazing land cluttered with clumps of young poplar, scattered mature trees, fallen logs and thickets of willow along a creek. None of the young had attained full power of flight. Mr. Baillie also secured a locally reared juvenile at Rainy River. These records add for the species, two new breeding stations, to the very few known in the province.

♂	June 19, Emo.	Imm. ♀	July 31, Rainy River.
Juv. ♀	June 24, Emo.		

Antrostomus vociferus. WHIP-POOR-WILL.—Heard only at Off Lake, on four nights between July 5 and 11. This region undoubtedly is on the northern periphery of range of this species and, as might be expected, it is scarce.

Chordeiles minor. NIGHTHAWK.—Observed regularly throughout the summer. The greatest number noted on one day was ten, on July 19, near the camp at Big Fork but seven had been seen on July 5 at Off Lake. A fresh egg was found at Clearwater Lake on July 1, situated on a bare rock denuded by fire.

The specimen collected, a female, has a wing measurement of 195 mm. and the tail measures 108 mm. Its dorsal surface presents a more variegated pattern of pale markings than is found on the average Night-

hawk from eastern Ontario and pale markings on the wing-coverts are extensive. The characters as described more or less combine the characteristics of *C. m. minor* and *C. m. sennetti*.

♀ July 1, Off Lake.

Chaetura pelagica. CHIMNEY SWIFT.—We rarely noted the Chimney Swift about farmland but it was observed fairly commonly in the more heavily forested region to the north and about the towns of the district. This distribution is consequent to the availability of nesting sites; original conditions for nesting in trees were undoubtedly present in the forest while chimneys in the villages, constituted suitable sites there.

♂ July 14, Big Fork.

Archilochus colubris. RUBY-THROATED HUMMINGBIRD.—Observed most regularly from our Off Lake camp, at which place the forest was more extensive and uninterrupted. As many as twelve were seen on one day, July 6. A nest containing two heavily incubated eggs was found at Aylesworth on June 25. It was situated on a horizontal limb of a bur oak approximately fifteen feet from the ground. The female bird attempted protection of the nest by making swift darts at the writer when he disturbed her.

♂ July 2, Off Lake.

Megaceryle alcyon. BELTED KINGFISHER.—This species was met with regularly at all stations on lakes and water courses but its territorial requirements are apparently too great to allow for more than a sparse population. An occupied burrow was found on Quill Lake on July 7. Young birds were not noted on the wing until July 20.

♂ June 25, Aylesworth.

Colaptes auratus. YELLOW-SHAFTED FLICKER.—Flickers were fairly evenly distributed throughout the region. From one to ten individuals were noted daily throughout the summer. It was the commonest woodpecker about areas under cultivation but one other species exceeded it to the north in the wilder parts, the Yellow-bellied Sapsucker.

Occupied nesting holes were discovered. The earliest observation pertaining to nesting was made on June 11 when a female was found working at a cavity in a dead tree.

♀ June 10, Emo. ♀ July 9, Off Lake.
♂ July 5, Off Lake.

Ceophloeus pileatus. PILEATED WOODPECKER.—The Pileated Woodpecker was recorded rarely from all our camps; one or two birds were noted on five occasions during the summer. It is fairly certain that the same pair was involved in two of these observations. It is therefore a widely scattered resident, perhaps not much scarcer now than at any former period. We did not find any occupied nests but nesting holes or winter roosts, unquestionably the work of this species, were seen.

♂ July 5, Off Lake.

Melanerpes erythrocephalus. RED-HEADED WOODPECKER.—The Red-headed Woodpecker was somewhat more generally distributed and numerous than might have been expected in this region which undoubtedly approaches the northern limits of its range. It seems probable that it is more numerous now than in earlier times. We saw the Red-headed Woodpecker at all camps but it was more regularly and commonly observed in districts where cultivated land was interspersed with woodland. Seven individuals were noted on June 25 near Emo. An occupied nest was found in a brushy pasture with scattered dead trees on June 20.

♂ June 3, Emo.	♂ June 20, Emo.
♀ June 10, Emo.	♂ June 27, Emo.
♀ June 20, Emo.	

Asyndesmus lewisi. LEWIS'S WOODPECKER.—The following record is included in this account of summer birds since the time of the observation, May 27, verges on a summer date. During our visit, to the western portion of Rainy River District in 1929 it was our pleasure to meet and become acquainted with Mr. Edgar Sullivan, a youth who was then interested in natural history and who has since continued that interest. On May 27, 1934, Mr. Sullivan wrote me as follows,—"I'm dropping you a line to let you know I saw a Lewis's Woodpecker to-day. According to 'Birds of Western Canada' this bird is a native of British Columbia and not known east of Saskatchewan. I can assure you of its being a Lewis's Woodpecker. I stopped the car within twenty-five feet of it, that we might observe it. It was sitting on a fence post, one-half mile south of Langtry's Bridge (near Emo)". Incidentally there is an excellent figure of this species in the publication to which Mr. Sullivan refers.

This record constitutes the first for Ontario but since it does not rest on a collected specimen it is probably best to regard it as hypothetical for the present. Further support to the record is given by the fact that this species has been seen in recent years in the Winnipeg region. (Cartwright, 1931).

Sphyrapicus varius. YELLOW-BELLIED SAPSUCKER.—Comparatively scarce in cultivated sections but it was the commonest woodpecker of wilder parts. A nest found on July 1 contained young birds.

♂ June 17, Emo.

Dryobates villosus. HAIRY WOODPECKER.—Observed regularly at all camps, somewhat more commonly in wilder sections, but it was not plentiful in any part of the district. Three was the most observed on a single day. We established the record of it as a breeding species on June 15, when young of the year were secured. The juveniles collected proved on dissection to reveal their sex by crown markings; coloured on young males and black on young females. The adult females collected are not notably large representatives of the species. Their average measurements are, L.246, cul. 31; W. 122.5; T. 80; Wt. 75. They may be regarded as somewhat intermediate between *D. v. villosus* and *D. v. septentrionalis*.

Juv. ♂ June 15, Emo.
Juv. ♀ July 3, Off Lake.
♀ July 4, Off Lake.
Juv. ♀ July 7, Off Lake.
♀ July 30, Rainy River.

Dryobates pubescens. DOWNY WOODPECKER.—The Downy Woodpecker was observed regularly at all camps. It was fairly common in wilder sections, somewhat less numerous near cultivated areas. On the average it outnumbered the Hairy Woodpecker for the region as a whole. Young birds of the year were first noted on July 2. As in the case of the Hairy Woodpecker, young birds were carefully dissected and the sex, so determined, substantiated the supposed sex characters of juveniles in this genus as has been discussed elsewhere (Snyder, 1923). The series of adult specimens average in size within the limits ascribed to the form *medianus*. One adult male, by general appearance possibly a non-breeding bird, taken on July 2, conforms well with the race *nelsoni*. The population as a whole may best be regarded as intermediate.

♀ June 12, Emo.
♀ June 27, Emo.
2 ♂ ♂ July 2, Off Lake.
♀ July 6, Off Lake.
♂ July 6, Off Lake.
Juv. ♂ July 6, Off Lake.
♀ July 8, Off Lake.
♀ July 24, Big Fork.
Juv. ♂ July 30, Rainy River.

Picoides arcticus. ARCTIC THREE-TOED WOODPECKER.—Met with between Clearwater Lake and Off Lake on three occasions; possibly representatives of a single family were concerned in each observation. No other records were secured for the species.

A young female specimen, undoubtedly reared near camp, was collected. It has two small white marks on a black feather of the

posterior back. The fore-crown is marked, as is probably the rule, with a small faint yellow spot.

Juv. ♀ July 8, Clearwater Lake. ♂ July 9, Off Lake.

Picoides tridactylus. AMERICAN THREE-TOED WOODPECKER.—On July 16, Mr. Baillie secured an adult of this species in a spruce bog not far from camp at Big Fork. This is the only record for the region.

♀ July 16, Big Fork.

Tyrannus tyrannus. EASTERN KINGBIRD.—Although the Kingbird was observed regularly and fairly commonly about the wilder lake country to the north, it was not as numerous there as it was about settled sections. It very probably has increased as a result of the clearing, or partial clearing, of the land. A newly completed Kingbird nest was found on June 15, situated five feet from the ground on the top of a burned stump. A thicket of low-growing willows shielded the stump and the nest probably would not have been detected if the adult birds had not flown at me fiercely. Although no eggs had been deposited as yet, the defence of the nest was definite enough.

♂ July 3, Off Lake.

Myiarchus crinitus. CRESTED FLYCATCHER.—We did not meet with this flycatcher about camp at Emo but it was noted at all other camps as a rare resident. Two family groups were observed near Rainy River on August 5, by Mr. Baillie.

♀ July 10, Off Lake. Juv. ♂ Aug. 5, Rainy River.

Sayornis phoebe. EASTERN PHOEBE.—Noted daily throughout the summer. Phoebes were least numerous in flat agricultural sections and most numerous about the lake shores to the north and along the rivers to the south. While exploring an abandoned farmstead, north of Emo, on June 12, a Phoebe's nest was discovered in a rather unusual situation. A root cellar, constructed by digging a hole approximately seven feet deep on level terrain, had been timbered over and roofed level with the ground. A vertical shaft gave access to the chamber which had partially filled with water. The Phoebe accepted this subterranean site which was strictly a hole in the ground rather than a cave, in the usual sense. A nest situated over the window of the log building in which we were encamped at Off Lake was a source of much pleasure and some annoyance. When the young Phoebes left the nest during the first week of July, countless thousands of minute mites which had infested the nest emigrated. Attracted perhaps by the warmer interior of our cabin the mites entered through the chinking between the logs

and for a couple of days their masses imparted large dusky patches to the ochre surfaces of the log walls and to the bunks in which we slept.

♂	June 25, Big Fork.	♂	July 15, Big Fork.
♀	June 27, Emo.	Juv. ♀	July 24, Big Fork.
♂	July 10, Off Lake.	♀	July 25, Big Fork.
♀	July 15, Big Fork.	Juv. ♂	Aug. 7, Rainy River.

Empidonax flaviventris. YELLOW-BELLIED FLYCATCHER.—The only record for the summer was made by Mr. Baillie in a wild plot near Big Fork on July 16th.

Empidonax trailli. TRAILL'S FLYCATCHER.—A fairly common flycatcher, noted at all camps. It was somewhat more numerous in sections where semi-clearings and second growth were prevalent, rather than where more virgin conditions prevailed; the species probably increased following settlement of the land.

Of the three adults collected one is slightly peculiar; the wing-bars are a shade darker than the average for this form, the head contrasts with the general tone of the back by being slightly darker, the grey band on the breast is darker and less tinged with greenish and the third primary is the longest (by 1 mm.) rather than being equal or shorter than the second. The bird was regarded as a characteristic example of *E. trailli* in the field however.

♂	June 1, Emo.	♀	July 29, Rainy River.
♂	June 15, Emo.	Juv. ♂	Aug. 3, Rainy River.

Empidonax minimus. LEAST FLYCATCHER.—The commonest flycatcher of the region. It was to be found in a considerable variety of habitats, in the alder thickets along streams, in the mixed forests, in poplar groves, etc. The species was noted nest-building on June 4. Young birds of the year were first noted out of the nest during the second week of July.

♀	July 1, Off Lake.	Juv. ♀	July 10, Off Lake.

Myiochanes virens. EASTERN WOOD PEWEE.—A fairly common species noted at all camps. Six was the greatest number noted on a single day. The drowsy call of the Wood Pewee was a characteristic sound of the older poplar groves. The more open mixed forest constituted a habitat for this flycatcher in the lake country to the north.

♂	June 13, Emo.	♂	July 1, Clearwater Lake.
♂	June 14, Emo.	♀	July 9, Off Lake.
♂	June 25, Aylesworth.		

Nuttallornis mesoleucus. OLIVE-SIDED FLYCATCHER.—Although we found the Olive-sided Flycatcher occupying the relic black spruce bog

in the settled section, it was more frequently observed in the wilder lake country to the north. It cannot be regarded as a common bird in the same sense as certain other flycatchers. Two pairs, established sufficiently close together that the calls of the male birds can be heard at the same time at a point between them, is about as dense a population, apparently, as this species attains.

♀ July 5, Off Lake.

Otocoris alpestris. HORNED LARK.—Clearing of the land for settlement in western Rainy River District has undoubtedly been favourable to the increase of the Horned Lark. We did not see the species in sections where natural conditions were little affected by man, but it was noted fairly commonly in farmed districts. Adults were seen carrying food on June 10 and the first flying young were noted on June 19.

A male taken on May 31 was the first specimen to be collected after we had established camp in the region. There seems little doubt that it was a migrant since it is distinctly not of the resident race. This individual measured as follows,—length 190 mm., culmen 18 mm., wing 106 mm., tail 69 mm., weight 43½ gms. The forehead and crown still display winter condition of the plumage and have a yellowish brown suffusion. The superciliary stripe is distinctly yellowish and the throat is yellow. Dorsally this bird is dark in tone and warm in colour. So far as tone and colour are concerned, the specimen compares favourably with examples of the form *alpestris*. Except for its large beak and rather small wing (somewhat worn) it is typical of this race.

Of the specimens subsequently collected and known to be the breeding form, three are adult males. Their average measurements are as follows:—length 180 mm., culmen 12 mm., wing 105.3 mm., tail 69.6 mm., weight, 32.8 gms. These birds are notably pale dorsally with light cinnamon drab on the occiput and nape. Two have very pale yellow throats and the third is nearly white. These birds are like summer examples of the Horned Lark from central and southern Manitoba and similar to birds from southeastern Saskatchewan (the latter, *enthymia* of Oberholser). They differ from summer Horned Larks from southern Ontario and southern Michigan in having lighter and on the average less extensive fuscous markings on the feathers of the back. The margins of paler colour on the dorsal feathers of Rainy River birds are broader and "light drab", not as warm in colour as on breeding birds from southern Ontario and specimens from Michigan. The colour and tone as given in detail imparts a generally paler aspect to the dorsal area as compared with specimens, from more south-

eastern localities, regarded as *praticola*. It would appear from an examination of material in the R.O.M.Z. collection that *O. a. enthymia* is a valid race and that its distribution should extend through southern Manitoba to the Rainy River region in Ontario. Birds of this region are similar to *O. a. articola*, but smaller, and similar to *O. a. leucolaema* but not so ochraceous.

♂	May 31, Emo.	Juv. ♀	June 19, Emo.
♂	June 6, Emo.	♂	June 19, Emo.
♂	June 10, Emo.		

Iridoprocne bicolor. TREE SWALLOW.—Found throughout the region, most commonly in the lake country and along the rivers. A nest with eggs was noted on June 7.

♀ July 3, Off Lake. Juv. ♀ July 23, Big Fork.

Riparia riparia. BANK SWALLOW.—Colonies were found along the Rainy River, at Emo, Big Fork and at the town of Rainy River. The small colony at Emo consisted of about eight pairs. The burrows were in a vertical bank of sawdust along the river where a sawmill had operated some years ago. The sawdust was well packed and although it was easier to tunnel in than earth, the site possessed a normal earth-bank appearance. Naked young were found in one of these tunnels on June 28.

Nestling (alcoholic) June 28, Emo. Juv. ♀ July 23, Big Fork.

Stelgidopteryx ruficollis. AMERICAN ROUGH-WINGED SWALLOW.—Mr. Baillie discovered this species near camp at Big Fork and counted as many as twenty-five individuals including young just out of the nest, on July 24. This constitutes the most northerly record for the species in Ontario and one of the most northerly for North America.

♀ July 20, Big Fork. Juv. ♂ July 20, Big Fork.

Hirundo erythrogaster. BARN SWALLOW.—Seen regularly and fairly commonly throughout cultivated areas where buildings for nesting sites were available. It was not noted during our stay in the lake country.

On June 25 we visited a heavily forested section on the Rainy River which formerly constituted an Indian Reservation. An abandoned farmstead in a clearing central to the forested area and several miles from settlements, was reconnoitered for birds and here one pair of Barn Swallows was found nesting in the stable. This was certainly the only pair established there. The male of this pair was collected

as a specimen about noon. In less than two hours another male was seen flying about the buildings with the resident female.

♂ June 25, Big Fork.

Petrochelidon albifrons. CLIFF SWALLOW.—We were told of several nests of this swallow on the outside eave of a barn four miles east of Emo and subsequently a set of eggs and also a nestling was secured from this situation. The only other record for the species for this region was one seen by Mr. Baillie on July 21, near Big Fork.

Nestling (alcoholic) July 25, Emo.

Progne subis. PURPLE MARTIN.—Seen regularly from all camps except at Off Lake. It nests about the town of Fort Frances, about villages and farmsteads of the region. We found the species occupying original sites for nesting, namely cavities in trees. A family was reared in an abandoned woodpecker hole situated twenty feet from the ground in a dead paper birch in an open wooded pasture near our camp at Emo. Mr. Baillie observed a flying young being fed by a female, while both birds were on the wing.

♂ June 24, Emo. Juv. ♂ Aug. 4, Rainy River.

Perisoreus canadensis. CANADA JAY.—This species was noted occasionally, but not commonly during the summer of 1929. Its occurrence about farmland was more or less accidental. Near Emo on June 16, during the early evening, a young Canada Jay was observed being pursued by a Crow Blackbird which apparently regarded it as a stranger in the locality. The jay was obviously frightened, as it flew to a brick farm building and clung to the wall. Later it escaped into a clump of bushes nearby. The species breeds in the region.

Juv. ♂ July 2, Off Lake. ♂ July 21, Big Fork

Cyanocitta cristata. BLUE JAY.—Not common but observed regularly; less frequent in wilder sections.

♂ June 5, Emo.

Corvus brachyrhynchos. AMERICAN CROW.—A common species of the region, most numerous in cultivated sections where there is undoubtedly a plentiful food supply and extensive situations for nesting.

The male bird collected is large in all its measurements, typical of the eastern form *C. b. brachyrhynchos*. Its measurements in millimetres are as follows:—length 495, total culmen 51, wing 332, tail 201, weight 480 gms.

Penthestes atricapillus. BLACK-CAPPED CHICKADEE.—Noted regularly throughout the summer, but the species became most conspicuous after about July 8, at about which time the young emerged from their nests. Twice during late summer when family groups were met with and collecting of specimens made it possible to determine the point, adult males were found to be the family escort.

The plumage condition of adults collected makes racial comparison very uncertain, both as regards tone and colour, and size. The series of five adult males when compared with specimens of the same sex and collected about the same date from extreme southern Ontario can not be certainly differentiated. The wear and loss of tail and wing feathers give an inaccurate measurement of these parts but even so they appear rather large for *P. a. atricapillus.* The average measurements for the five, given in millimetres, are as follows:—length 137, wing 65.5, tail 66.5, weight 11.5 gms.

2 ♂ ♂	June 12, Emo.	2 ♂ ♂	July 9, Off Lake.
♂	July 1, Off Lake.	Juv. ♀	July 17, Big Fork.
Juv. ♀	July 9, Off Lake.	Juv. ♀	July 29, Rainy River.

Penthestes hudsonicus. BROWN-HEADED CHICKADEE.—This chickadee was rare in the region but it was noted twice during the late summer when family groups were met with. On both occasions these birds were discovered in black spruce cover,—local boreal islands.

The material collected is not sufficiently satisfactory to be very helpful in determining the race of this species occurring in the area. Comparisons of the juveniles show them to be very similar to juveniles taken elsewhere in Ontario. A casual examination of adults in the R.O.M.Z. collection which might suggest the racial probabilities for Rainy River merely indicated the need for a general study of Canadian Brown-headed Chickadees.

2 Juv. ♂ ♂	July 16, Big Fork.	Juv. –	July 21, Big Fork.

Sitta carolinensis. WHITE-BREASTED NUTHATCH.—A rare bird of the region; found only at or near Big Fork along the Rainy River. Woods containing old broad-leafed trees constituted its habitat. Such particularly characterized the Indian Reserve of the region.

Sitta canadensis. RED-BREASTED NUTHATCH.—Seen at all camps but an uncommon species. Found in old, dense, mixed woods, the habitat overlapping that of the White-breasted Nuthatch at Big Fork.

Certhia familiaris. BROWN CREEPER.—Noted only on three occasions during the summer, once at Off Lake and twice at Big Fork. It was found on each occasion in old and dense mixed forests, in situations

favourable to the occurrence of the last-mentioned species. The form of the region is the Eastern Brown Creeper, *C. f. americana.*

Adult June 25, Big Fork.

Troglodytes aedon. HOUSE WREN.—A fairly common bird and found at all camps; most numerous about habitations or clearings and partial clearings. A completed nest was found as early as June 1st, but young birds did not become conspicuous until mid-July.

The series of specimens secured are readily referable to the form *T. a. parkmani,* the Western House Wren.

♂	June 8, Emo.	♂	July 5, Clearwater Lake.
♂	June 12, Emo.	♀	July 8, Clearwater Lake.
♂	June 17, Emo.	♀	July 16, Big Fork.
♂	June 20, Emo.	♀	Aug. 3, Rainy River.
♀	June 27, Emo.		

Nannus hiemalis. WINTER WREN.—This species was recorded at three of our camps,—Off Lake, Big Fork and Rainy River,—but it was very rare in all localities. Typical white cedar swamps which apparently provide the most acceptable habitat for Winter Wrens were uncommon. The birds we discovered were all found in old black spruce stands. The only specimen collected was lost down one of the innumerable holes about the roots of spruce in a dark, wet bog.

Cistothorus stellaris. SHORT-BILLED MARSH WREN.—An uncommon species, noted at three of our four camps, Emo, Off Lake, and Rainy River. Young birds not long out of the nest were secured.

♂	June 1, Emo.	Juv. ♂	July 30, Rainy River.
♂	July 8, Off Lake.	Juv. ♀	Aug. 7, Rainy River.

Dumetella carolinensis. CATBIRD.—Noted occasionally at all four camps. A nest containing a set of three fresh eggs (probably an incomplete clutch) was collected on June 5 near Emo. This species is known to extend slightly north of this region (Baillie and Harrington, 1936 and 1937).

♂ June 5, Emo. ♀ July 20, Rainy River.

Toxostoma rufum. BROWN THRASHER.—Found only near camp at Emo where it was a rare bird. The Rainy River District appears to be on the northern periphery of the range of this species in this longitude.

♂ June 5, Emo.

Turdus migratorius. AMERICAN ROBIN.—A common breeding species throughout the region.

Juv. ♀ June 12, Emo. Juv. ♀ July 2, Off Lake.

Hylocichla guttata. HERMIT THRUSH.—A fairly common breeding species found throughout the region. Relic woods in cultivated sections are sufficiently numerous and extensive to support a Hermit Thrush population but slightly less numerous than in the wild areas of the lake country, according to our daily observation records.

♀	June 6, Emo.	Juv. ♂	July 7, Off Lake.
♂	July 1, Off Lake.	♂	July 16, Big Fork.
Juv. ♀	July 6, Off Lake.		

Hylocichla ustulata. OLIVE-BACKED THRUSH.—This species was not observed at our Emo camp but it was found commonly at Off Lake. It was also an uncommon species at Big Fork and Rainy River. A nest with four eggs, found on July 4, at Off Lake, was successfully photographed together with an adult by Mr. A. R. Van who was in the field with us during the period.

♂	July 4, Off Lake.	Juv. ♂	July 9, Off Lake.
Juv. –	July 5, Off Lake.		

Hylocichla fuscescens. WILSON'S THRUSH.—A common breeding species throughout the region. Comparison of the series of specimens collected at Rainy River has presented an interesting problem as regards the racial variation of this species throughout its range in Ontario. The specimens from Rainy River tend distinctly towards olive brown dorsally. When viewed in series they contrast markedly from the more tawny olive birds from southern Ontario. There can be no doubt that the Rainy River specimens represent the form *H. f. salicicola*, the Willow Thrush.

2 ♀ ♀	June 4, Emo.	♀	June 13, Emo.
♂	June 6, Emo.	♂	June 22, Emo.
♂	June 11, Emo.	♂	June 25, Aylesworth.
		♂	July 3, Off Lake.

Sialia sialis. RED-BREASTED BLUEBIRD.—The Bluebird was noted fairly regularly but not commonly from all camps in or in the vicinity of cultivation. It was not noted at the Off Lake camp. A nest with small young was found at Emo on June 20.

♂	June 20, Emo.	Juv. ♀	July 31, Rainy River.
♂	July 17, Big Fork.		

Bombycilla cedrorum. CEDAR WAXWING.—Found throughout the region; common in the lake country, somewhat less so elsewhere. Nests with eggs were noted by July 1. On July 3 the Cedar Waxwing was noted on our daily record sheet as "abundant", a term rarely employed by us to describe the status of a species during field work. Their numbers continued at a peak throughout the first week of July. Two

reasons account for the large numbers observed. First, the species was actively engaged in mating and nest-building during this period and was consequently conspicuous: second, the emergence of Ephemerids from the water attracted them to the open lake shores where they fed on these insects.

♀ June 15, Emo.		♀ Aug. 7, Rainy River.
♀ July 3, Off Lake.		

Lanius ludovicianus. COMMON SHRIKE.—An uncommon species of the cultivated districts. A nest containing five half-grown young was found on June 8 near Emo. It was situated in a densely-branched shrub willow along a creek in a cultivated field. A dense mat of sheep wool had been used for lining material. One young bird was retained as a camp pet, and, until its escape on June 25, it proved a source of much interest. It accepted bits of meat regularly at the skinning table and at other times captured flies for itself at the windows of the old building in which we were camped. After a meal of blue-bottle flies it would disgorge a pellet of chitin about the size of a bean. It never attempted escape from the house unless all members of the party were outside at which time it became restless. It was while we were away from camp that it managed to find a hole in the fly screen of the door and started its independent career.

The two adult birds collected, represent a mated pair. The female is in much more worn plumage than is the male. The feathers of her scapulars and rump are grey or greyish and are judged not to have been extensively white even when fresh. These tracts are white or whitish on the male and the feathers on the back and head are slightly paler than those of the female. With the material at hand for comparison it seems evident that western Rainy River District is on the border range of the forms *L. l. migrans* and *L. l. excubitorides*.

4 Juv. ♀ ♀ June 8, Emo.		♀ June 8, Emo.
		♂ June 8, Emo.

Sturnus vulgaris. COMMON STARLING.—This species had not reached the district at the time of our visit in 1929, but recent reports from residents indicate that it had reached there by 1935. Mrs. Down living near Devlin writes (May 1938) that during "the last three years there have been some here" and that during the present season Starlings nested in a shed-building on their farm. Miss Beatrice Sturdy, a school teacher interested in birds, also reports the species about Fort Frances though it is as yet not numerous. Its widespread occupancy of settled sections of the western Rainy River District is to be expected in the next few years.

Vireo solitarius. SOLITARY VIREO.—A rare species noted only once during the summer, at Off Lake on July 10th.

Vireo olivaceus. RED-EYED VIREO.—A common species throughout the region. The earliest breeding record was made on June 1st when a completed nest was found.

♂ July 3, Off Lake. ♂ July 4, Off Lake.

Vireo philadelphicus. PHILADELPHIA VIREO.—An uncommon species identified occasionally near Emo and at Off Lake.

♂ June 13, Emo. ♂ July 5, Off Lake.

Mniotilta varia. BLACK AND WHITE WARBLER.—Seen almost daily from all camps but six was the greatest number recorded on a single day. It is therefore regarded as a fairly common warbler of the region.

An unsexed specimen, presumably a male, collected on July 19, is in fresh incompletely developed winter plumage. The skull is soft and the field notes indicate that it is immature. This plumage differs markedly from the adult. All but a narrow median area of the ventral surface is rather heavily streaked with black. The throat, foreneck and upper breast are white as are also the sides of face and auriculars. Dorsally the specimen is similar to an adult male.

♂ June 14, Emo. Juv. – July 19, Big Fork.

Vermivora peregrina. TENNESSEE WARBLER.—Fairly common at Big Fork, where there were extensive black spruce forests, rare at Off Lake and not seen elsewhere.

♂ July 8, Off Lake.

Vermivora ruficapilla. NASHVILLE WARBLER.—Fairly common at all camps except at Rainy River where it may have been missed because of the cessation of song since our visit there was rather late in the summer.

A nest containing three eggs and a Cowbird's egg in a partial state of incubation was found by Mr. Baillie on July 18 at Big Fork. The nest was located about three feet up from ground-level, in upturned roots of a fallen evergeen in a dense mixed woods. The female bird was collected.

♂ June 15, Emo. ♀ July 18, Big Fork.

Compsothlypis americana. PARULA WARBLER.—Common in the older and denser mixed woods at Off Lake and occasional at Big Fork; not noted elsewhere. A juvenile bird just out of the nest is one of

the rarer plumage-specimens obtained during 1929. Incidentally the taking of this bird constitutes the first positive breeding evidence for the species in Ontario. The form of the region is *C. a. pusilla* and the juvenile plumage of this race is like that described by Ridgway (1902) for the Southern Parula (*C. a. americana*) except that the feathers of the chin and upper throat are whitish (like those of the abdomen), not pale yellow.

♂ July 6, Off Lake. Juv. ♀ July 9, Off Lake.
♀ July 9, Off Lake.

Dendroica aestiva. YELLOW WARBLER.—This species nested about the village of Emo and was not rare at Off Lake. Family groups and individuals were also noted occasionally at Rainy River.

♂ July 3, Off Lake. Juv. — July 30, Rainy River.
♂ July 30, Rainy River. Imm. ♀ July 31, Rainy River.

Dendroica magnolia. MAGNOLIA WARBLER.—Fairly common breeding species in wilder sections to the north; noted rarely elsewhere.

♂ July 2, Off Lake. Juv. ♂ July 9, Off Lake.
♂ July 5, Off Lake.

Dendroica coronata. MYRTLE WARBLER.—Found regularly but not commonly in the region of Off Lake; not noted elsewhere. This species apparently prefers the pine stands in the more open, dry, rock country.

♂ July 6, Off Lake.

Dendroica virens. BLACK-THROATED GREEN WARBLER.—The species was noted regularly and fairly commonly from our Off Lake camp and rarely at Big Fork.

♂ July 9, Off Lake.

Dendroica fusca. BLACKBURNIAN WARBLER.—A rare species throughout the area visited but noted somewhat more regularly in the wilder parts. Young of the year, noted at Off Lake and at Rainy River, gave evidence that the species is a breeding bird of the region.

♂ June 10, Emo. ♀ July 6, Off Lake.

Dendroica pensylvanica. CHESTNUT-SIDED WARBLER.—A common nesting warbler of the region. The earliest record for the appearance of young in the nest was made on June 27.

♂ June 10, Emo. ♀ July 25, Big Fork.
♂ July 9, Off Lake. Imm. ♀ Aug. 5, Rainy River.

Dendroica castanea. BAY-BREASTED WARBLER.—Found commonly in the wild parts to the north; recorded once at Rainy River. On July 5th at Off Lake, a female Bay-Breasted Warbler was observed carrying some material into the dense spire of a tall spruce tree. It was probably food for young birds judging by the date but may have been nesting material.

2 ♂ ♂ July 1, Off Lake. ♀ Aug. 3, Rainy River.

Dendroica striata. BLACK-POLL WARBLER.—The taking of a female Black-poll Warbler on August 5 at Rainy River is the only record for the species we secured. This occurrence is regarded as marking an early migratory date since this bird is scarcely to be expected as a summer resident in this latitude. The specimen is in worn summer plumage and as noted during the preparation of the specimen, has a bare belly. Some plumage replacement is evident, especially on the coverts of the wings.

♀ Aug. 5, Rainy River.

Dendroica pinus. PINE WARBLER.—This species was recorded as an uncommon warbler at Off Lake. It was recorded once at Rainy River. The species breeds in the region, as indicated by the observation of broods and the collecting of juveniles. Dissection of the female collected on June 8 revealed an egg in the oviduct. Two young birds secured from a family group on July 31 show a considerable difference in the stage of plumage development. One is entirely in the dull juvenile plumage and the other has a considerable replacement of the drab grey-brown feathers of the throat and breast by bright greenish-yellow feathers of the first winter plumage. At Off Lake this warbler was found only in rather open stands of well-developed pines in high dry rocky situations.

♂ July 5, Clearwater Lake. 2 Juvs. — July 31, Rainy River.
♀ July 8, Clearwater Lake.

Dendroica palmarum. PALM WARBLER.—The taking of a juvenile female by Mr. Baillie on July 21 established this species as a rare breeding bird of the region which incidentally is the second for the province. The bird was collected in a black spruce bog.

Juv. ♀ July 21, Big Fork.

Seiurus aurocapillus. OVEN-BIRD.—Common throughout the region but more evenly distributed in the north because of the continuity of woodland. Young birds out of the nest were first noted on July 5.

♂ June 14, Emo.

Seiurus noveboracensis. NORTHERN WATER-THRUSH.—Not common but observed regularly at Off Lake. It was noted once near Emo. Comparison of the specimens secured with the series in the Museum merely indicates that a much broader study of Ontario material than can be attempted for the present report, is needed.

♂ July 4, Off Lake.	♂ July 5, Off Lake.

Oporornis philadelphia. MOURNING WARBLER.—Common throughout the region. A nest containing one egg was found by Mr. Stovell on June 16 near Emo. It was situated just off the ground in a brush pile in a small clearing where trees for winter wood had been removed. It was determined, on a subsequent visit to the place, that the nest had been destroyed by some unknown agent.

♂ June 1, Emo.	♂ July 9, Off Lake.
♂ June 3, Emo.	♂ July 17, Big Fork.
♂ July 8, Off Lake.	♂ Aug. 6, Rainy River.

Geothlypis trichas. MARYLAND YELLOW-THROAT.—This warbler was not particularly common but it was generally distributed and observed regularly throughout the summer. The first evidence that young of the year had hatched was secured on June 27 when a female was observed carrying food.

The series of adult males secured average slightly brighter green dorsally than specimens from southern Ontario, regarded as typical of *G. t. brachidactyla*. Also the pale band across the fore-crown averages wider and paler than typical *brachidactyla*. Ventrally, the Rainy River birds show, in series, a slightly warmer yellow than a comparable series from southern Ontario but on the other hand they are not as bright as birds from the prairie region (*G. t. occidentalis*). The average measurements of the six adult males are as follows:—L. 123.5 mm., cul. 11.2 mm., W. 55.5 mm., T. 48.5 mm. (worn), tar. 19.3 mm., Wt. 10 gms.

As described, the Maryland Yellow-throat from this region is somewhat intermediate between the Northern Yellow-throat, *G. t. brachidactyla* and the Western Yellow-throat, *G. t. occidentalis*.

The females secured are too worn to be of much value in comparative work.

♂ June 11, Emo.	♀ July 25, Big Fork
♂ June 14, Emo.	Juv. ♂ July 30, Rainy River.
♂ June 17, Emo.	♂ Aug. 1, Rainy River.
♂ June 27, Emo.	♀ Aug. 3, Rainy River.
♂ July 4, Off Lake.	Juv. ♀ Aug. 6, Rainy River.

Wilsonia canadensis. CANADA WARBLER.—Fairly common at Off Lake and noted occasionally at Big Fork.

Setophaga ruticilla. AMERICAN REDSTART.—An uncommon species in areas altered by clearing and cultivation but fairly common in the wilder parts to the north. A second year male collected was singing a short but characteristic Redstart song.

Imm. ♂ July 3, Off Lake. ♂ July 4, Off Lake.

Passer domesticus. ENGLISH SPARROW.—This introduced species is fairly common about towns, villages and farms throughout the settled portion of western Rainy River District. It nests about habitations.

Juv. ♀ June 15, Emo.

Dolichonyx oryzivorus. BOBOLINK.—On June 16th, 1929, near Emo, a bird flew past our camp which was provisionally recorded as a Bobolink. Subsequent observation did not again reveal the species and the record was withheld. Since then Mr. D. E. MacMillan, an Ontario Game and Fisheries Overseer who formerly lived near Emo, has visited there and in late June of 1936, and again in 1937, he saw an individual male in a meadow three miles north-east of the village. This is consistent with recently noted range expansions (see Baillie and Harrington, 1937).

Sturnella neglecta. WESTERN MEADOWLARK.—Not uncommon about cultivated farmland and open pastures from Rainy River to Fort Frances. Although the species penetrates northward for several miles particularly in the central region, it was not observed in sections beyond cultivation. A female collected on June 15th contained a well-developed egg in the oviduct. Four young birds were noted in a nest found near Emo on June 26th. This is the first definite evidence of breeding for this species in the province. No exact date as to the advent of this Meadowlark into the region could be determined, but there seems no doubt that it has come to occupy the area within recent years, probably within the present century.

♂ June 3, Emo. 2 ♂ ♂ June 5, Emo.
♀ June 5, Emo. ♀ June 15, Emo.

Agelaius phoeniceus. RED-WINGED BLACKBIRD.—Fairly generally distributed in marshy habitat throughout the area and not uncommon at all camps made; most common in the lake country. A nest containing three eggs was found at Off Lake on July 1st.

The series of specimens collected are readily referred to the form *A. p. arctolegus* on the basis of measurements which average as follows:—Three mature males: L. 67.6 mm., W. 125.8 mm., T. 97.5, cul. 24.3, Depth at base, 12 mm., Wt. 67.6 gms. Three females (wings, and tail feathers worn); L. 196 mm,, W. 100.5 mm., T. 71 mm., cul. 18.6 mm.,

depth at base 10.8 mm., Wt. 41 gms. Both sexes in series exhibit the colour characters attributed to the form.

♂	June 4, Emo.	2 Imm. ♂ ♂	July 3, Off Lake.
♂	June 18, Emo.	♀	July 8, Off Lake.
♀	July 3, Off Lake.	♀	July 10, Off Lake.
♂	July 3, Off Lake.		

Icterus galbula. BALTIMORE ORIOLE.—Rather an uncommon species but observed throughout the region and established as a breeding bird. The first brood of young observed out of the nest was on July 7 at Off Lake. The two males collected are somewhat more brilliant in colour than the average for males in the Museum's series from southern Ontario.

♂	June 6, Emo.	Juv. ♀	July 9, Off Lake.
♂	June 27, Emo.	Juv. ♀	July 19, Big Fork.
♀	July 5, Off Lake.		

Quiscalus quiscula. CROW BLACKBIRD.—Common and noted regularly in all areas visited. Many nests were found in early June in the vicinity of Emo. Young out of the nest were noted near the end of June and by the first week of July (at Off Lake) large flocks had congregated.

Juv. ♀ June 30, Emo. ♀ July 17, Big Fork.

Molothrus ater. COWBIRD.—Observed at all camps; common about farmland but less numerous in wilder sections. The species has undoubtedly increased since the advent of agriculture in the region.

The adult female collected, though indicating the racial probabilities of the species in the region, would scarcely be sufficient basis for even a tentative conclusion. However, a good series of specimens from a section of Ontario adjacent to western Rainy River District, aids greatly in the matter. Female Cowbirds from this region average warmer in colour below and on the side of the head, and possess, on the average, more extensive and conspicuous dark shaft marks on the feathers of the ventral surface than birds from southern Ontario. The pale area on the throat of eastern birds shows a great deal of individual variation in conspicuousness. In the western series at hand this character is markedly uniform. The series of specimens from the west shows a tendency toward a slender beak, i.e., compressed laterally at the middle.

The average measurements of six males from this region are: L. 195.8, W. 111.6, T. 75.4, Exposed culmen 17.4. The average measurements of eight females from this region are: L. 179.7, W. 101, T. 69.8, exposed culmen 15.8. These measurements are intermediate between measurements of eastern birds as taken from southern Ontario summer

specimens and the measurements (of males) tabulated by Grinnell (1909) for western birds.

The Cowbird population of this portion of western Ontario probably was derived from the south (*ater*) and from the west (*artemisiae*).

♀ June 4, Emo. Juv. ♀ July 30, Rainy River.
Juv. – July 21, Big Fork.

Piranga erythromelas. SCARLET TANAGER.—Met with rather irregularly in the more southern districts probably because of the discontinuity of the forest, but the species was regularly observed in the wilder parts of the north. It was not common in any district, which is more or less a characteristic status of the species in any part of its range. Singing males, found in definite and restricted situations during the summer, were the nearest approach to establishing the breeding status of this species in the region.

♀ July 1, Off Lake. ♂ July 2, Off Lake.

Hedymeles ludocivianus. ROSE-BREASTED GROSBEAK.—Observed regularly but not commonly at all camps. A young of the year, undoubtedly reared locally, was collected.

♂ June 17, Emo. Juv. – June 19, Big Fork.

Hesperiphona vespertina. EVENING GROSBEAK.—Observed on three occasions from our camp at Emo, one on June 1, one on June 5, and four on June 6. On June 7 eight adults were found in a scattered flock in the town of Fort Frances. They were feeding about the box elders in the small park in the centre of the town's business section. The female specimen collected (a characteristic representative of the form *H. v. vespertina*) had a bare belly and was alone in a heavy, old mixed woods near Emo. Another lone individual was seen on July 6 at Off Lake.

♀ June 1, Emo.

Carpodacus purpureus. COMMON PURPLE FINCH.—This species was recorded regularly from all camps. A nest with fresh eggs was found at Off Lake on July 12. It was situated 35 feet from the ground near the top of a balsam fir in an old dense mixed forest. The nest was found to be built of usnea moss interspersed with the stems and fine stocks of some dry plant. The female, collected on June 1 near Emo, possessed a well-developed egg in the oviduct.

♀ June 1, Emo. ♂ July 18, Big Fork.
♂ June 10, Emo.

Spinus pinus. PINE SISKIN.—This species was noted irregularly during the summer at Emo and at Off Lake. It was seen singly, or in flocks, without respect to the advance of the summer.

Spinus tristis. AMERICAN GOLDFINCH.—A common species throughout the region, slightly less numerous in wilder, more heavily forested sections. The two males collected have been carefully compared with birds from southern Ontario. The yellow of the ventral surface of these birds is purer, more nearly a lemon chrome, not as lemon yellow as specimens from southern Ontario. Abrasion of the feathers of the wings prohibits a satisfactory comparison as to their pale edgings. The white markings on the tail are not notably extensive. The two specimens present the following average measurements: L. 123.5, W. 72.2, T. 49.2, exposed culmen (one specimen) 11.5, Wt. 12.5 gms. These measurements are but slightly larger than those of a series from southern Ontario. With the mention of a slight tendency toward the western form *S. t. pallidus*, the Rainy River specimens are referred to the eastern form, *S. t. tristis*.

♂ June 13, Emo. ♂ Aug. 6, Rainy River.

Passerculus sandwichensis. SAVANNAH SPARROW.—This species has undoubtedly increased in this region since the establishment of clearings for farms. We observed it as regular, common and well-distributed throughout sections visited, within the range of cultivation. It was not seen in the wilder lake country to the north. A nest with four fresh eggs was found near Emo on June 6. It was situated in a three-inch depression in the ground bordering a hay-field.

Comparison of the Rainy River series of specimens with summer birds from southern Ontario (regarded as *P. s. savanna*) shows some significant differences. The Rainy River specimens have a generally paler aspect dorsally. They are more finely-marked, i.e. the black stripes on the dorsal feathers average narrower and there is an absence of the slight brownish tint of eastern birds, which colour borders the black dorsal stripes on many of the southern Ontario specimens. Below, the dark markings are somewhat sparser than on eastern birds. There is a notable tendency in the Rainy River specimens toward a pale or whitish superciliary stripe.

Compared with specimens from northeastern Utah (regarded as *P. s. nevadensis*) the Rainy River specimens are not as pale and have a distinctly longer beak. Specimens from northeastern North Dakota are like the Rainy River specimens in colour, tone and pattern, but they possess shorter beaks. (Av. 9.4 mm.). Specimens from the

southern prairie provinces are similar to the Rainy River birds but it has been noticed that the dark breast streaks tend to become paler westward. The juvenile bird from Rainy River is paler than juveniles from the east. The average measurements of the nine males from Rainy River are: L. 135.6, W. 67.8, T. 48.3, exposed culmen 11.2, Wt. 17.9 gms.

Although our understanding of the distribution and variation of this species is in an incomplete state and certain nomenclatural problems are still to be settled, the writer would refer the Savannah Sparrow of western Rainy River District to the form, *P. s. alaudinus*, within the A. O. U. (1931 Check-list) meaning of the name, or *P. s. campestris* of Taverner.

♂	June 5, Emo.	♀	June 27, Emo.
♀	June 6, Emo.	♂	June 27, Emo.
♂	June 17, Emo.	♂	July 17, Big Fork.
♂	June 19, Emo.	Juv. ♀	July 19, Big Fork.
♂	June 22, Emo.	2 ♂ ♂	July 25, Big Fork.
		♂	July 29, Rainy River.

Pooecetes gramineus. VESPER SPARROW.—A common species, only slightly less so than the Savannah Sparrow, and similarly distributed. We did not observe the species at the Off Lake camp. Undoubtedly this species has also flourished with the clearing of the land. It nests about the fields and pastures, young in the nest being evidenced by parent birds carrying food, on June 15, and subsequently.

The series of adult specimens has been compared with a series from southern Ontario and found appreciably paler dorsally, slightly more sparsely and narrowly streaked on the breast, and distinctly larger. The tawny brown wing-mark, characteristic of the species, is also markedly paler. They are very similar to specimens from Manitoba and the prairie provinces. Juveniles from Rainy River are also paler than eastern birds of like age.

The average measurements of five males collected are as follows:— L. 162.8, W. 82.5, T. 63, exposed culmen 12.6, Wt. 26.7 gms. The Vesper Sparrow of this region is referable to the western form *P. g. confinus*.

♂	June 4, Emo.	2 ♂ ♂	June 22, Emo.
♂	June 6, Emo.	Juv. ♂	July 31, Rainy River.
♂	June 15, Emo.	♂	Aug. 1, Rainy River.
♀	June 22, Emo.	Juv. ♂	Aug. 3, Rainy River.
		Juv. ♀	Aug. 3, Rainy River.

Junco hyemalis. SLATE-COLORED JUNCO.—An uncommon species but noted occasionally at all camps. Evidence of breeding was noted

on June 21, when a female was seen procuring deer hair for a nest. The form of the region is *J. h. hyemalis*.

♀	June 21, Emo.	Juv. —	July 21, Big Fork.
♂	June 21, Emo.		

Spizella passerina. CHIPPING SPARROW.—Not common but generally distributed; seen most regularly at our Off Lake camp. A nest was found in the town of Fort Frances on June 7th.

Comparison of the specimens secured has been made with a large series across Ontario. Both the grey and rufous colours of the plumage show a marked paleness as compared with specimens from southern Ontario. Final comparison was made with washed skins from the east to eliminate the possible effect of dirt and discoloration. The differences as noted above were still apparent.

The four adult specimens without segregation by sex give an average measurement as follows:—L. 137, W. 74, T. 59, exposed culmen 10.3, Wt. 12.9 gms. These averages are larger than for southern Ontario birds, similar to western Canadian representatives of this species and similar to specimens from western U. S. (Utah) but do not average quite as pale as the latter. The Chipping Sparrows from Rainy River, though somewhat intermediate, are referred to the western form, *S. p. arizonae*.

♂	June 17, Emo.	♂	July 8, Off Lake.
♀	June 25, Emo.	♂	Aug. 7, Rainy River.

Spizella pallida. CLAY-COLORED SPARROW.—A common species throughout the cleared portions of the region; rare in wilder sections to the north. The species is established as a nesting bird as indicated by our having collected young of the year. It seems probable that this sparrow has come to occupy the Rainy River District within comparatively recent times, perhaps the present century.

3 ♂ ♂	June 3, Emo.	♂	July 15, Big Fork.
♂	June 17, Emo.	♂	July 29, Rainy River.
♀	June 20, Emo.	Juv. ♀	Aug. 1, Rainy River.
♀	June 22, Emo.	Juv. ♀	Aug. 4, Rainy River.
		♂	Aug. 6, Rainy River.

Zonotrichia albicollis. WHITE-THROATED SPARROW.—A fairly common species through most of the area; common in wilder sections. Several nests were found during the summer, the earliest, containing three eggs, was noted on June 5, near Emo.

♂	July 10, Off Lake.	Juv. ♂	July 31, Rainy River.
♂	July 17, Big Fork.		

Melospiza georgiana. SWAMP SPARROW.—Observed regularly but not commonly at all camps in the region. Young birds, obviously reared locally, were observed late in the summer at Rainy River.

♂	July 3, Off Lake.	♂	July 26, Big Fork.
♂	July 9, Off Lake.		

Melospiza melodia. SONG SPARROW.—A common species throughout the region. A set of four fresh eggs (and one Cowbird egg) was collected at Off Lake on July 5th. This would appear to be a second clutch since flying young were in evidence during this period of the summer.

Comparison of the series of specimens secured leaves no doubt that the Song Sparrow population of western Rainy River District is of the Dakota Song Sparrow race, *M. m. juddi*.

♀	June 1, Emo.	♀	July 3, Off Lake.
♀	June 11, Emo.	2 ♂ ♂	July 3, Off Lake.
♂	June 11, Emo.	♀	July 6, Off Lake.
♂	June 17, Emo.	Juv. ♀	July 7, Off Lake.
♀	June 19, Emo.	♂	July 15, Big Fork.
♀	June 20, Emo.	♂	July 24, Big Fork.
		♂	Aug. 7, Rainy River.
		Juv. ♀	Aug. 8, Sable Island.

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TRANSACTIONS

OF THE

Royal Canadian Institute

No. 48 OCTOBER, 1939 VOL. XXII, PART 2

ESTABD 1849

ROYAL CANADIAN INSTITUTE

ROYAL CHARTER 1851

THE NATURAL RESOURCES OF KING TOWNSHIP, ONTARIO, 1938*

K. M. Mayall

Introduction

THE Township of King, York county, Ontario, is an area of nearly 140 square miles, its centre about twenty miles north-north-west of the city limits of Toronto. (Map 1). From Yonge street, which marks most of its eastern boundary, the township extends westward fifteen miles to the Peel county line. The southern boundary is Vaughan township, and the northern is Simcoe county and the west branch of the Holland river.

Most of the township is rolling or hilly country, with a well-marked divide running from east to west across its centre. This ridge is the height of land between lake Ontario and lake Simcoe. Streams rising on the abrupt northern slopes of the township drain rapidly down to the flat land of the Holland marsh, where a canal diverts the waters around a part of the marsh now reclaimed, and on into the west branch of the Holland river and lake Simcoe. From the southern slopes the streams drain more slowly, forming tributaries of the Humber river, which crosses the south-western corner of the township on its way to lake Ontario. Included in the township are twelve small moraine lakes. All of these lie south of the height of land.

Altitudes vary from a minimum of about 670 feet, on the Humber, to more than 1,200 feet on the ridge.

The mean annual temperature is 43° Fahrenheit. The average daily maximum temperature varies from 80° in July to 25° in February, and the average minimum from 56° in July to 7° in February. Normal annual precipitation is 28.94 inches. The total average snowfall is close to four feet. These figures refer to Oak Ridges in the east end of the township.

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*The Survey of King Township as reported here was suggested and financed by Mr. Aubrey Davis of Newmarket, Ontario. An advisory board consisting of members of the staff of the University of Toronto, the Royal Ontario Museum of Zoology and the Secretary of the Ontario Hunters' Game Protective Association assisted in directing the survey.

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Map 1. Location of King Township
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" 5. Woodlots
" 6. Water
" 7. Cleared Land now Uncultivated
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" 9. 1938 Plan

SETTLEMENT AND POPULATION

The first white settlers arrived near the site of Nobleton before 1790, coming north from Kleinburg, through the woods which then covered the whole township. In 1794, Governor Simcoe, who had traversed the Indian portage across the township from the Humber river to a point on the Holland river in the previous year, chose and surveyed the route of Yonge street. In 1800, when the township was first surveyed, there were twenty residents.

The abundance of water power, the heavy stands of available timber and the rich clay loam soils which covered much of the township, made it an attractive region for settlement; but regular communications were lacking until 1825. In that year Lewis Bapp first ran a "light covered wagon for the accommodation of travellers between York and Holland Landing". The population then rose rapidly. Sawmills, woollen or carding mills, grist mills and tanneries were rapidly built, and by 1842 there were more than 2,500 people in the township.

The linking of Toronto and Aurora by railway in 1854 brought a further influx of settlers, bringing the population to a peak of 7,500 in 1871. Already by that date almost all the available farming land was cleared and cultivated. The falling off of the local industries since that time in the ten villages in the township has caused a steady drop in the population, which was listed in 1936 as 4,636.

OCCUPATIONS

The population of King township is widely scattered, and concerned almost exclusively with mixed farming, oats and wheat being the commonest grain crops. Nearly all farms have a herd of dairy cattle. Very few farmers keep sheep. There is one large fruit farm, where apples are grown for the Toronto market. Formerly all the cleared land was owned or rented by farmers, but in 1937 twelve per cent of the cleared land was in the hands of non-resident (city) owners, either held for resale or used for summer residences.

The sole remnant of the former industrial activity in the township is a planing mill at Schomberg. The three remaining grist mills are at Schomberg, Kettleby, and Kinghorn. None of them use water-power.

Distributing centres include the large villages of Schomberg and King, and lesser settlements at Nobleton, Kettleby, Lloydtown, Pottageville, and Laskay. Other settlements include two large private schools, one community farm, and one eight-hundred-acre farm run by a resettlement organization.

A recent development is the attempt to establish a market garden settlement on the peat soil of the Holland marsh, reclaimed in 1927. So far the expense of draining the marsh does not appear to have been justified.

In 1938 a dehydrating plant was built and opened at Schomberg. In this plant alfalfa is rapidly reduced to a more efficient fodder. Thirty men will be employed six months per annum at this work.

METHODS OF SURVEY

Maps. Base maps were prepared on a scale of 4 inches to the mile from enlargements of the military maps covering the area.

Interviews. There are about 620 farms of more than 25 acres now being worked. More than 90 per cent of these farms were visited. Forms were prepared on which the basic data obtained from interviews with 504 farmers were written. The information was recorded covering soil, water, wildlife, vegetation and available tree-planting land. With few exceptions all the woodlots in the township were visited. The farmers' estimates of acreage of woodlands were checked against the woodlands estimates for each farm in the township assessment book. Wherever there was a doubt about the reliability of these figures they were checked against a complete oblique aerial photographic survey of the township. For this survey the roads and fences were considered to be satisfactory grid lines.

A representative census was made of the opinions and wishes of the farmers concerning hunting and game.

Animal Census. The purpose of the bird census work was to have a representative set of population figures for the township in its present condition for comparison with any possible future conditions. R. D. Ussher, B.Sc.F., and D. A. Ross were engaged for the summer months to make studies of the population density of birds, particularly, and other wildlife, on sample strips and plots selected as average for each type of cover in the township. Ussher and Ross also made an extensive general survey of the population and breeding grounds of the larger birds, such as ducks, pheasants, partridges, hawks, and owls, which could not be censused by the sample plot or strip method.

Ducks. The wild duck population of the township, as observed by Ussher and Ross, showed such unusual differences in density on particular ponds, that a special investigation of nine selected waters was made during September by W. K. W. Baldwin, M.A. The location, grouping, water level and depth, and the types of shore line of these

waters were studied. Close to 500 food and cover plants were collected and identified.

Fish. The project is indebted to Professor Harkness and Professor Dymond for their cooperation in examining many of the streams of the township. Representative samples of the fish and invertebrate fauna were taken in June by seining at typical places on all the permanent streams and several temporary streams in the township. The types of water, the temperatures, and the bank cover were also recorded, with recommendations for possible improvement work. An additional study was made of two of the streams in August.

Headquarters. Work was begun in the township on May 1st, with headquarters at King Creek farm. During July the headquarters were moved to Pottageville, for two weeks, and then to Kettleby, and field work was continued from there until December 21st. When in January draughting facilities were required, space was made available in the Biological Building of the University of Toronto, through the cooperation of Professor Harkness and the Department of Biology. Here large scale maps were prepared for demonstration purposes, of which the maps included in this report are reduced copies.

Literature. All the available information on the ownership and area of individual lots in the township was made available to the survey by the Reeve and Council of King township, to whom this survey is greatly indebted.

The work of the survey was greatly simplified, so far as ground water, soils, and wildlife were concerned, by reference to three reports:

(1) A faunal investigation of King Township, York County, Ontario, by L. L. Snyder and E. B. S. Logier. Contributions to the Royal Ontario Museum of Zoology, No. 3, 1930.

(2) The physiography of South Central Ontario, by D. F. Putnam, and L. F. Chapman. Ontario Research Foundation. 1936.

(3) A report of the Dominion of Canada Soil and Ground Water Survey, Department of Mines and Resources, Ottawa. 1937.

Record. The detailed record of all work done, information obtained from interviews with farmers and others, recommendations, maps and plans, is on file and available for reference at the Royal Ontario Museum of Zoology, Toronto.

SOILS

The geological history of King township has given rise to three main types of soils. The distribution of these soils is shown on Map 3.

There is no rock outcrop. The Lorraine and Utica shales underlying

the area are throughout overlain by clays or sands more than a hundred feet thick.

1. *Kame Area* (Map 3). Most of the Kame Area is what is known to the farmer as "light land". The ridge of hills across the township consists mainly of sands and gravelly clays, with some coarse gravel. The bedrock now covered by this ridge lay between two parallel lobes of the Wisconsin or last retreating ice sheet. Torrential meltwaters carrying sand and gravels from the glacial drift laid down these soils. Silts were laid down in slower moving waters. The steep slopes and the light and rather acid soil make much of this land totally unsuited to agriculture.

2. *Peat and Muck Soil Area*. The valley of the Holland river was once the floor of a bay of glacial lake Algonquin. The sediments in this lake accumulated forming a heavy clay. After the shrinking of lake Algonquin this bay became an arm of lake Simcoe, and aquatic vegetation appeared in the shallow waters. The clay beds which lie in shallow ridges and pockets were gradually (for at least 2,000 years)* overlain with from four to twelve feet of peat. The flatness of the valley and the clay ridges prevent rapid drainage and hence the water table is still close to the surface of the peat.

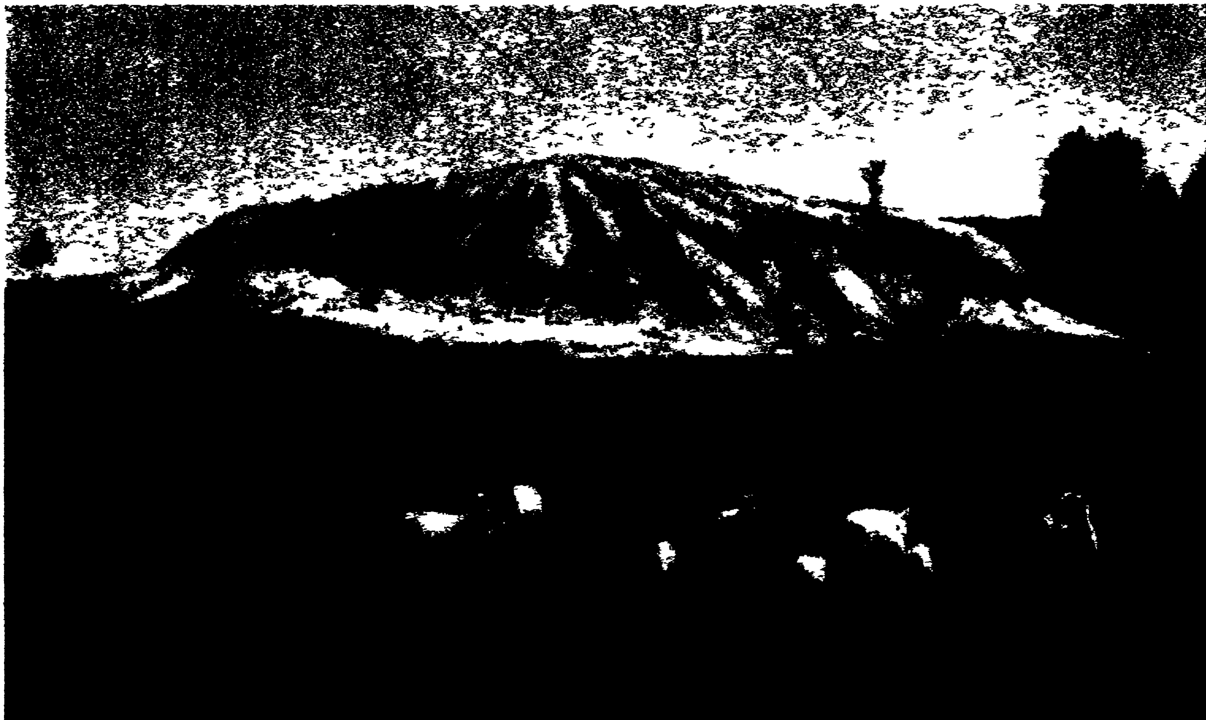
Favourable reports of the possible value of the peat soil for market garden crops led to the drainage of 7,250 acres of this land in 1927. A dyke now encloses the reclaimed area, cutting off a part of the Holland river** which winds through the marsh. The outside swamp water is carried off by a canal outside the dyke, and all water collecting on the drained area passes into the old course of the Holland river, and is pumped out at Bradford bridge. Since there is now little or no current in the Holland river, it is rapidly becoming silted and overgrown with vegetation, thereby further impeding the drainage.

3. *Clays and Clay Loams*. In the remainder of the township the soil consists for the most part of clays, clay loams, and silts. There are lacustrine sediments (varved clays and silts), ground and terminal moraines, which are unmodified glacial drifts, and lastly alluvial silts of recent origin.

Most of the soil in this area, being developed from calcareous till, makes excellent farming land, but the soil is far from uniform. Within the major clay and loam area many types of soil occur, the land varying from the limestone rock flour of the Schomberg clay, with over 50 per cent

*Applying the average of three estimates for rate of growth of peat. *Ecology*, Vol. XIII, No. 1.

**The Schomberg river (Map 3), also called the Holland river, is the west branch of the Holland river.



ERODED HILLS

KING TOWNSHIP, ONTARIO.

This waste land, unfit for crops or pasture, will still grow trees Black Locust and Carolina Poplar will stabilize the soil, making way for more valuable species later

calcium carbonate, to the many small lenses of fine sand which occur sporadically throughout the township. East of Schomberg the boulder-strewn and sandy shore line of old lake Algonquin can also be seen in many places, forming land suitable only for pasture or forestry.

TABLE 1

A SUMMARY OF THE PHYSIOGRAPHIC REGIONS OF KING TOWNSHIP

CLAY AND LOAM SOILS			
(Good farming land)	Ground moraine	20,000 acres	
	Terminal moraine	34,000 "	
	Schomberg lake plain	3,000 "	
	Alluvial silts	6,000 "	63,000
PEAT SOILS	Algonquin lake plain	12,000 "	12,000
KAME AREA	Interlobate deposits	13,000 "	13,000
(Some good farming land, but mainly light sands and gravelly clays).			*88,000 acres

FORMER CONDITIONS

In appraising the significance of the present situation in King township, some knowledge of the former conditions is essential.

At the time of settlement, King township, apart from the flat open valley of the Holland marsh, was covered with a heavy growth of mixed hardwood and coniferous forest. The township lies in the Transition Zone between the deciduous forests of the Niagara-lake Erie region and the coniferous forests of northern Ontario.

The most striking feature of the forest in this zone was the wide variety of major dominant tree species. The prevailing tree association was one with trees of all ages present, the Sugar Maple-Beech climax, a northern extension of the deciduous forests. These trees were often intermixed with White Ash, White Elm, Red Maple, Yellow Birch, Hornbeam, Basswood, Black Cherry, Red and White Oak, and Large Toothed Aspen. The great tolerance to shade of the Maple-Beech association, and the favourable climate and soil, caused it to encroach gradually northward on the competing and less tolerant coniferous forest after the retreat of the last ice front. The relicts of the former southern extension of the coniferous forests, White and Red Pine and Hemlock, occupied the cool northern slopes, the deep valleys and many of the sandy ridges of King township.

Where destructive fires and windfalls opened up clear areas, White Birch, the Aspens and the two Pines formed second growth even-aged stands within the mass of deciduous forest. White Cedar played a secon-

*This acreage does not include road allowance, which is a total of about 1,700 acres.

STUMP FENCE

These White Pine stumps are relics of the former dense forest which covered King township. The sandy ridge land shown is no longer of value to the farmer who owns it. Under the King township plan it would be reforested.

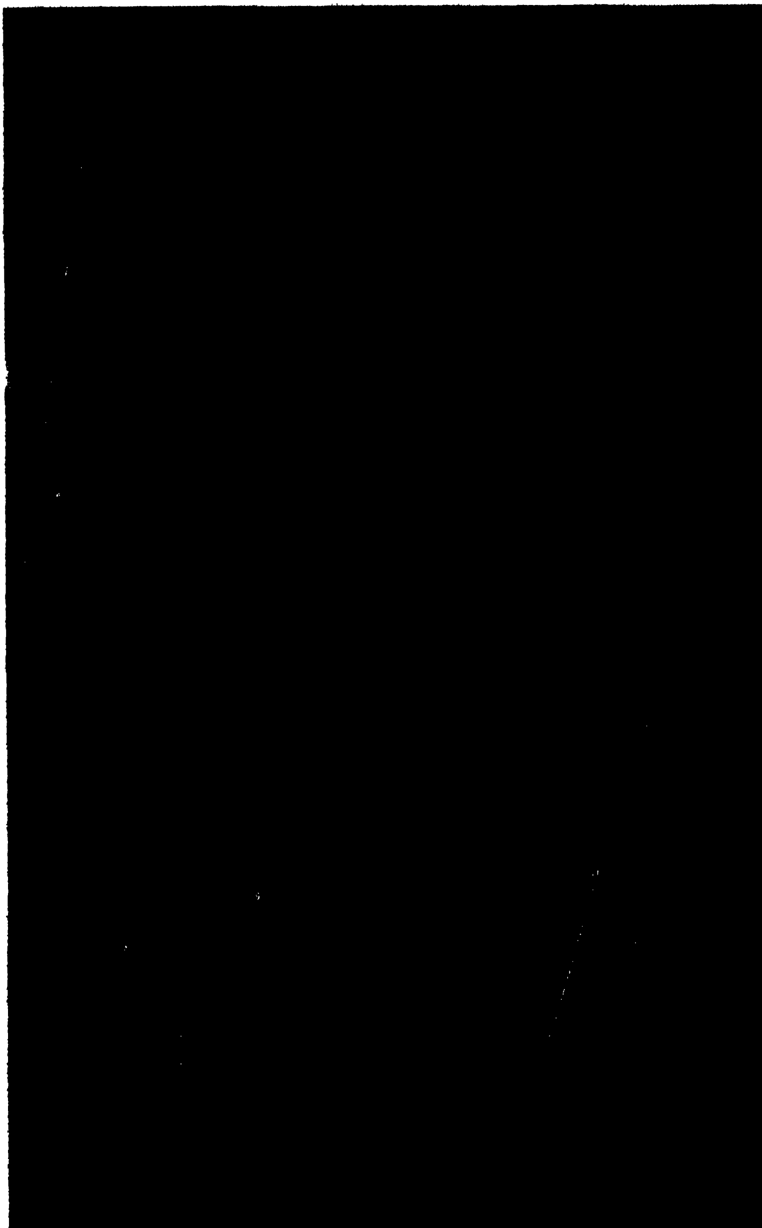
dary role in the forest. Its inability to compete with the rapid-growing species on dry soils confined it to the wetter valleys and the swamps, accompanied by Black Ash, Black Spruce, Alder and Willow, and occasionally Elms. The Tamarack, even more sensitive to competition and less sensitive to high soil moisture than the White Cedar, fringed the Holland marsh and the small moraine lakes lying at the base of the southern slopes of the watershed. Two grasses* dominate the open Holland marsh vegetation, separately forming almost pure carpets thousands of acres in extent.

Such was the appearance of the township before the coming of the settler.

The clearing and settlement of the land followed three main routes north and east from Nobleton, west from Oak Ridges, and west from Aurora to Lloydtown. A generalized summary of the woodland cover about 1840 is shown in Map 4. This date was chosen for study because at that time there was little or no damage from erosion or water loss, and the country probably supported a maximum of game and the larger forms of wildlife. Close to two hundred miles of large and small streams ran permanently from springs in the watershed. Most of these streams were well stocked with brook trout and other fish. Many small swamps held a further reserve of water. The newly cleared and humus-filled land needed little fertilizing to produce heavy crops. The many forest edges, where cleared fields and both open and closed woods offered a wide variety of food and shelter, supported a flourishing population of game, fur and other wild animal life.

At that time more than 60 per cent of the township was still uncleared. But already the wooded areas were rapidly being cut over for square timber, lumber, shingles, fence posts and rails. By 1851 there were twenty-one sawmills in operation in the township. The peak of lumber production was probably reached about 1860. The removal of mature timber in itself had little permanent effect on the soil water and wild animal population of the township. The clearing and grazing of woodlands were more significant. The effects of this heavy drain on the covered land of the watershed were soon felt. By 1890 clearing and overgrazing of the high lands had continued to such an extent that much of these lands no longer retained their moisture through the summer. The rain falling on the ridges drained rapidly down to lake Ontario and lake Simcoe, removing much of the topsoil as it went. Many of the small swamps throughout the township were drained to increase the farming land. The lowered water table cut off the flow from many

**Calamagrostis canadensis* Michx, Beaux, and *Agrostis stolonifera* L.



LAND WITHOUT WOODS

An aerial photograph of part of King township, including the village of Schomberg. There are no woodlots on this land. (The dark patches are cloud shadows.)

springs, ending the fish life in the streams they fed. At the same time extensive trapping and hunting reduced the wildlife population.

As the wood reserves were depleted, the sawmills gradually went out of business. The Cedarvale mill at Pottageville, which had been the first stationary sawmill to operate in the township, was also the last remaining one. It was dismantled and sold in December, 1937.

PRESENT CONDITIONS

GROUND COVER

The basic conditions of ground cover and surface water as of January, 1938, are shown on maps 5 and 6. These maps are reduced copies of the more accurate large scale maps (scale 4 inches to one mile), prepared for demonstration purposes.

Since the Holland marsh area is not typical of the township as a whole and since a large part of it has been set apart under the provincial Holland Marsh Drainage Act, it has been treated separately, and no recommendations with regard to its future are included in this summary. An arbitrary line marking off some 6,000 acres of the marsh area as a separate unit is shown on map 3.

Amount of Tree Cover. The percentage of wooded land required to maintain a sufficient water supply for farm use and to ensure soil conservation and wildlife shelter varies according to soil type, climate, the slope of the land, method of agriculture and the species of trees involved. In rolling land such as the township of King there is no doubt that at least 15 per cent of well spaced ungrazed woods is essential.

It will be seen from Table 2 and Map 5 that only 4,042 acres, or 4.9 per cent of the township, now remains in ungrazed woods. These figures exclude the Holland marsh area but include the Pottageville woods. A further 4,499 acres of land is covered with woods or pastures in which overgrazing has left little or no young growth present. Such woods are no longer efficient in water-holding capacity. They supply no sustained yield of fuel for the farmer, and they provide little or no shelter for wildlife. The addition of all the overgrazed woods to the present ungrazed woods in the township would only raise the percentage of all types of cover in the area to 10.4 per cent. The results of the survey of water conditions and soil erosion show that this percentage is quite inadequate to keep the land in a stable condition for the best use of its inhabitants.

Character of Tree Cover. The previous cuts have greatly affected the character of the remaining tree cover in the township. The woodlots tend to lie in continuous strips parallel to the concession lines and in the

centre of each lot, since the clearing of each half lot of 100 acres began from the nearest road, working gradually back to the centre of the concession. Hence, apart from the central ridge woods, the location of woodlots on particular farms has little or no relation to poor soil conditions but is a haphazard arrangement.

Weed trees such as Hornbeam have increased owing to their being left uncut when the more valuable trees were taken. More than 90 per cent of the present woodlands is composed of deciduous associations. Only a few small stands of White and Red Pine now remain, but the many stump fences show the former importance of these species. Most of the deciduous stands, being of second growth origin, following early logging, show a high proportion of trees more than 35 years old. Control of the annual growth in such stands is difficult. Even if heavily overgrazed and low in basal area per acre, having no young growth present, they still show a considerable increase in total volume every year. Such woodlots will become mere pastures dotted with stumps, when the present stands are removed, unless they are fenced from cattle and replanted immediately.

The end of cultivation of former fields has led to the development in the township of cedar pastures, grassy slopes with many young White Cedars scattered over them. There is much of this land on the northern slopes of the township, facing the Holland marsh.

The age of individual woodlots is of little fundamental importance in this report, since all woodlots handled on the basis of sustained yield contribute permanently to the preservation of the soil, water, and wildlife, whatever the age of the oldest trees, and whatever the particular method of cutting. But it should be noted that the present high proportion of even-aged woodlots of age exceeding 35 years will certainly result in a heavy drain on the timber in the township in the near future.

Present Volume of Standing Cordwood. The woodlands of King township include many different forest types and many degrees of site and stocking.* In such lands any estimate of standing wood not based on a percentage cruise can be at the best only a careful guess, but it is necessary to make an estimate of the present value in King township for comparison with possible growth and volume in future years.

Since the saw-timber in the township is no longer sufficient to keep a permanent sawmill at work, estimates will be based on total volume of "forest cordwood". At the time of settlement large areas of King township undoubtedly carried timber of 100-120 cords per acre. The estimates

*A statistical analysis of two typical woodlots in the township has been prepared, and is available for reference.

of W. N Millar for York county, in the Dominion Fuel Board "Report on the Fuelwood of Ontario, 1924", showed 700,000 cords of fuelwood contained in 47,400 acres of woodland, an average of about 14 cords per acre of woodland

The woods in King township may show a higher average than the above since there is more woodland not on occupied farms in King town-

AN OVERGRAZED WOODLOT

This woodlot, containing the only tree cover on a 1,000-acre section of land near Schomberg, consists of five acres of heavily overgrazed hardwoods, with no young trees present Trampling of the ground by cattle has disturbed the delicate relations between roots soil and soil-water Hence many of the trees are now dead or dying

The woodlot could be restored to a healthy condition by the following simple means removal of all unproductive trees, fencing of the woodlot from cattle; and the planting of all available space with valuable species such as White Ash. The five acres would then be a valuable asset to the farm, producing an annual crop of wood, conserving soil moisture, and incidentally providing food and shelter for wildlife

ship than over the county as a whole and hence less overgrazed woodlands, and since the many second-growth stands have been increasing rapidly in volume since that estimate was made. But heavy cutting in some areas has reduced a part at least of the increase, and 14 cords per acre may be taken as a fair average in the township over woods of all kinds, grazed and ungrazed. The 8,500 acres of woodland in King township (exclusive of the Holland marsh), will thus contain about 120,000 cords of standing wood. At least 23,000 cords, estimated, of fence material is also available as possible fuel-wood.*

Present and possible growth. Almost all the woodlots in King township are seriously understocked. Most have a heavy preponderance of the less desirable species. In very few is there any attempt at scientific management. The Dominion Fuel Board Report states, in part: "Not over 10% of all classes of woodlots (*in York county*) are producing within 50% of the possible annual increment in wood volume per acre." It is improbable the average growth exceeds 0.6 cords per acre per annum. No data are available on the possible growth in well-managed mixed woods in Ontario, handled on the basis of sustained yield. But the hardwood forests of the Michigan Agricultural College have been yielding at the rate of 1.2 cords per acre per annum, without reducing the growing stock. At this rate, if well managed, ungrazed and replanted in part, the 8,500 acres of woods now in King township would produce more than 10,000 cords per annum, without reducing the growing stock, instead of the present probable growth of about 5,000 cords per annum with a continual drop in the growing stock from woodlands ruined by overgrazing.

TABLE 2

SUMMARY OF WOODLANDS IN KING TOWNSHIP

Woodland type	Exclusive of Holland Marsh 82,240 acres		In Holland Marsh 6,000 acres	Total in Township 88,240 acres	
	Woodland area	Per cent of total in that area	Woodland area	Woodland area	Per cent of total for township
Ungrazed woods	4,042	4.9	1,125	5,167	5.8
Overgrazed woods....	4,499	5.5	12	4,511	5.1
Total covered lands...	8,541	10.4	1,137	9,678	10.9

*Deduced from figures in the Dominion Fuel Board Report, with allowance for the rapid removal of wooden fence material now taking place.

ROLLING LAND IN KING TOWNSHIP

An aerial photograph of the village of King and the land to the west. On this type of land a fair proportion of woods remains, but the watercourses are not protected. The banks of the Humber river (east branch), which runs from right to left across the centre of the picture, and of the small creek in the foreground, could be easily planted with protective belts of trees. These would help to conserve water and control erosion, besides providing a continuous yield of lumber for the farmers concerned.

Very few farmers in King township consider the pasture obtained in woodlands to be of much value. The cost of fencing is probably the chief reason for the overgrazing of woodlots in the township.

WATER

Of the 200 miles of permanent streams which formerly drained the township, only about 30 miles now remain. (Map 6). One example, which could be duplicated in many parts of the township, may show the great extent of the change. The Hall's lake stream formerly supplied a permanent flow of water on which two factories and six mills, one of them with three pairs of stones, depended. This same stream was dry in 1936, and could not now in an average year run a single pair of stones.

Twenty-eight mill ponds, which formerly held a constant supply of water for milling, are now reduced to one pond, every dam except one having failed. Local dam builders are responsible for this condition, caused by failure to increase spillway capacity of the dams as the deforestation increased the maximum rate of discharge. These dams were built to withstand average annual maximum discharge but could not even withstand floods to be expected in a ten-year period, as is seen in the case of the Kettleby dam, which has failed five times in the last fifty years.

The mill ponds, with the permanent lakes and natural ponds formerly existing, made up more than 500 acres of water surface, apart from the rivers. The present permanent water surface in King township, exclusive of rivers or canals, is less than 200 acres.

The Bureau of Geology and Topography, of the Dominion Department of Mines and Resources, carried out a ground water survey including King township, during 1937. Of 1,572 wells in the township examined during the course of the survey, 264 no longer can be relied on to supply a permanent flow of water, and 72 others, while permanent, no longer supply enough water for the needs of the farmers concerned. These facts lead to only one conclusion : that the ground water, or reserve of water supplying springs and wells, has been seriously lowered since the main woodlands in the township were cut off. It is interesting to note that the four permanent streams now draining the township all have their origin in areas of ungrazed woodland.

Coincident with the lowering of the ground water level there has been a noticeable increase in the number and severity of both spring and summer floods.

WILDLIFE

In planning a survey of wide scope, to be completed in a single season, no time was available for methods of trial and error. One basic assump-

tion was made : that the nature and quantity of stream flow, water reserve, and tree cover were the fundamental factors controlling soil conditions and wildlife populations. Since stream flow and water reserve themselves depend mainly on available tree cover, the main effort of this project was concentrated on the woodlands survey.

The low percentage of woods remaining, and the fall in ground and surface water have already been shown. The effect of these changes on the wildlife population must now be estimated.

The detailed survey, "A faunal investigation of King Township" by L. L. Snyder and E. B. S. Logier (1930) has made unnecessary most of the ground work which would ordinarily have been needed in studying the animal life of the township. The information recorded in interviews with farmers and trappers in 1937, and the census work of R. D. Ussher and D. A. Ross, substantially agreed with the findings of the Museum census.

I. Mammals

Little is left of the dense population of game, fur and other mammals which formerly inhabited the township. Winter trapping is still carried on along the edges of the Holland marsh and the principal watercourses. Sixteen trappers were interviewed. All of them reported the near extinction of all the larger fur bearers in King township.

Some examples may indicate the general situation. The last lynx was shot in 1883, the last bear in 1888. The beaver colonies long ago deserted the township, though one beaver at least paid a visit to the drainage canal in the township while the 1937 survey was in progress.* A few muskrat and skunk are still trapped, and occasionally mink and raccoon.

The Holland marsh and the remaining woodlands on the untillable ridges have protected several species, such as the porcupine and the varying hare, which are seldom now found in adjacent areas of southern Ontario.

On the edge of the marsh the second growth hardwoods have provided an excellent habitat for the white-tailed deer. At least four groups of deer were present in 1937. They show no tendency to yard in winter. A few pass the summer on the central wooded ridges, returning to the marsh area for the winter. Their route crosses the main road east of Pottageville. Some are illegally shot every winter, and some have been killed by dogs, but they are not subject to attack by wolves, and appear to be increasing in numbers. The locations of the four groups of deer

*Remnants of old beaver dams are reported at Nancy Lake Farm, and also on a creek near the eighth concession road a mile east of Nobleton.

in December, 1937, are shown on Map 5. The total number of deer in the township is close to forty. Estimates by those living on and near the marsh have been as high as 400, and most were over fifty. The deer undoubtedly do some damage to fall wheat, in the fields close to the marsh.

The complete change in habitat conditions in King township from the former well-wooded lands to the present open type is well shown by the rapid increase in numbers of the European hare. This open-land species, first introduced at Brantford, Ontario, in 1922, and unrecorded in the township until 1925, has become in twelve years the commonest game animal in the township. Unlike the other newcomer, the ring-necked pheasant, it easily survived the severe winter of 1933-34. Most of the farmers in the township are pleased to see the hare shot, as it does considerable damage to fall wheat. The cottontail, considerably less abundant than the European hare, does little damage, apart from destruction of tree plantations. It is found only in swales and thickets.

The groundhog or woodchuck, not strictly a game animal, has been hunted persistently for many years. It is very common on all the higher lands in the township, and is an easy shot for the inexperienced sportsman. It does much damage to pastures and grain fields, and hence is shot by many farmers, some of whom took advantage of the bounty offered on groundhog snouts in 1936-37 by the Toronto and North York Hunt Club. This Hunt, which for many years hunted the red fox in King township, is now reduced to drag-hunting in that area, as foxes are too scarce to yield sport. Few foxes have beeen caught by trappers in recent years. The huntsman believes there are now "less than five" foxes in the twenty-five square miles of the township hunted over by the club.

The intensive census of the smaller mammals carried out on sample plots, shown on Map 9, in 1937 by D. A. Ross was intended only as a measure of comparison of present abundance with that of future years, and will not be discussed in detail here. Ross reported that "mice" in general were not sufficiently common in the township to cause much damage to crops or trees during the summer of 1937. Latest indications are, however, that the meadow mouse has caused a great deal of damage to both hardwood and conifer seedlings and saplings during the winter of 1937-38.

The mammals now remaining in King township include the following species.

Star-nosed Mole	Little Brown Bat
Cinereous Shrew	Big Brown Bat
Smoky Shrew	Silver Haired Bat
Mole Shrew	Raccoon

Bonaparte Weasel
New York Weasel
Mink
Skunk
Red Fox
Woodchuck
Eastern Chipmunk
Red Squirrel
Black or Grey Squirrel
Northern Flying Squirrel
Baird White-footed Mouse
White-footed Mouse
Bog Lemming
Meadow Mouse
Muskrat
House Rat
House Mouse
Meadow Jumping Mouse
Woodland Jumping Mouse
Porcupine
Varying Hare
European Hare
Cottontail
White-tailed Deer

It has already been mentioned that in its vegetation King township lies in the Transition Zone between the deciduous forests of the lake Erie region and the northern coniferous forests. The above list shows the fauna also to be a mixture of northern and southern species. The occurrence of the cottontail and the porcupine in close proximity in the township is an example of this transitional character of the fauna.

II. Birds

King township has a greater variety of bird life than most areas of its size in southern Ontario. This is due to the exceptionally wide range of ecological conditions in the township.

The survey of the summer birds of the township made in 1926 by the Royal Ontario Museum of Zoology made an excellent foundation for the present census. This survey, together with more recent bird records by several ornithologists, particularly by R. D. Ussher, who lives in the township, makes possible the following list of 212 species which now occur, or have occurred, at all seasons, in King township.

I. *Permanent Residents, Breeding*

Ruffed Grouse
Common Pheasant
Great Horned Owl
Pileated Woodpecker
Hairy Woodpecker
Downy Woodpecker
Blue Jay
Black Capped Chickadee
White Breasted Nuthatch
Common Starling
English Sparrow

II. *Summer Residents, Breeding*

Pied-billed Grebe
American Bittern
Least Bittern
Mallard Duck
Black Duck
Blue-winged Teal
Sharp-shinned Hawk
Cooper's Hawk

Red-tailed Hawk
Red-shouldered Hawk
Marsh Hawk
American Sparrow Hawk
Virginia Rail
Sora Rail
Common Gallinule
Killdeer Plover
American Woodcock
Spotted Sandpiper
Black Tern
Mourning Dove
Passenger Pigeon
Yellow-billed Cuckoo
Black-billed Cuckoo
American Screech Owl
Whippoorwill
Nighthawk
Chimney Swift
Ruby-throated Hummingbird
Belted Kingfisher
Yellow-shafted Flicker
Red-headed Woodpecker
Yellow-bellied Sapsucker
Eastern Kingbird
Crested Flycatcher
Eastern Phoebe
Traill's Flycatcher
Least Flycatcher
Eastern Wood Pewee
Horned Lark
Tree Swallow
Bank Swallow
American Rough-Winged Swallow
Barn Swallow
Purple Martin
American Crow
Brown Creeper
House Wren
Winter Wren
Long-billed Marsh Wren
Short-billed Marsh Wren
Catbird
Brown Thrasher
American Robin
Wood Thrush
Veery
Red-breasted Bluebird
Golden-Crowned Kinglet
Cedar Waxwing
Common Shrike
Red-eyed Vireo
Black and White Warbler
Nashville Warbler
Yellow Warbler
Black-throated Green Warbler
Blackburnian Warbler
Chestnut-sided Warbler
Pine Warbler
Oven-Bird
Northern Water-thrush
Mourning Warbler
Maryland Yellow-throat
Canada Warbler
American Redstart
Bobolink
Meadowlark
Red-winged Blackbird
Baltimore Oriole
Crow Blackbird
Cowbird
Scarlet Tanager
Rose-breasted Grosbeak
Indigo Bunting
American Goldfinch
Eastern Towhee
Leconte's Sparrow
Savannah Sparrow
Vesper Sparrow
Slate-coloured Junco
Chipping Sparrow
White-throated Sparrow
Lincoln's Sparrow
Swamp Sparrow
Song Sparrow

III. *Regular Summer Residents, No Breeding Evidence*

Great Blue Heron
Green Heron
Broad-winged Hawk
Yellow Rail
Wilson's Snipe
Herring Gull
Warbling Vireo
Common Purple Finch
Henslow's Sparrow

IV. *Irregular, or Very Rare Summer Visitors**

Little Blue Heron
Black-crowned Night Heron
Upland Plover
Grey Partridge
Olive-sided Flycatcher
Red-breasted Nuthatch
Yellow-throated Vireo
Prothonotary Warbler
Golden-winged Warbler
Magnolia Warbler
Myrtle Warbler
Cerulean Warbler
Pine Siskin
Grasshopper Sparrow

V. *Migrants*

Common Loon
Red-throated Loon
Red-necked Grebe
Horned Grebe
Double-crested Cormorant
Canada Goose
Snow Goose
Blue Goose
Gadwall
Baldpate
Pintail
Green-winged Teal
Shoveller
Wood Duck
Redhead
Ring-necked Duck
Scaup Duck
Common Golden-eye
Buffle-head
Old-Squaw
Hooded Merganser
Common Merganser
Red-breasted Merganser
Turkey Vulture
Common Rough-legged Hawk
Bald Eagle
Osprey
Peregrine Falcon
Pigeon Hawk
Semi-Palmated Plover
Black-bellied Plover
Common Turnstone
Solitary Sandpiper
Greater Yellow-Legs
Lesser Yellow-Legs
Knot
Pectoral Sandpiper
Least Sandpiper
Dunlin
Semi-palmated Sandpiper
Ring-billed Gull
Bonaparte's Gull
Caspian Tern
Barred Owl
American Long-eared Owl
Saw-whet Owl
Yellow-bellied Flycatcher
Cliff Swallow
Hermit Thrush
Olive-backed Thrush
Grey-cheeked Thrush
Ruby-crowned Kinglet
American Pipit
Blue-headed Vireo
Philadelphia Vireo
Tennessee Warbler
Orange-crowned Warbler
Parula Warbler
Cape May Warbler
Black-throated Blue Warbler
Bay-breasted Warbler
Black-poll Warbler
Palm Warbler
Connecticut Warbler
Black-capped Warbler
Rusty Blackbird
Cardinal
Clay-coloured Sparrow
Field Sparrow
White-crowned Sparrow
Fox Sparrow
Lapland Longspur

*Some of these are regular migrants.

TABLE 3

BIRDS OF KING TOWNSHIP

TYPE	Total Population Pairs/100 acres	Number of Species	5 COMMONEST SPECIES with population in pairs per 100 acres				
			1	2	3	4	5
Poplar Alder	**189**	**30**	Veery 19·3	Maryland Yellow-throat 17·1	Song Sparrow 15·0	Swamp Sparrow 12·8	Alder Flycatcher 10·7
Mixed Lowland Bush	**188·3**	**33**	Northern Water Thrush 17·5	Black-capped Chickadee 15·5	Chestnut-sided Warbler 13·6	Song Sparrow 13·6	Robin 11·6
Willows	**150**	**17**	Maryland Yellow-throat 35·6	Swamp Sparrow 25·0	Song Sparrow 21·3	Short-billed Marsh Wren 14·2	Alder Flycatcher 10·7
Coniferous Swamp	**142·8**	**21**	Maryland Yellow-throat 28·8	Alder Flycatcher 20·2	Song Sparrow 14·4	Nashville Warbler 8·6	Cowbird 8·6
Alders	**138·8**	**14**	Veery 19·9	Maryland Yellow-throat 19·9	Black Duck 13·2	Catbird 13·2	Swamp Sparrow 13·2
Ungrazed 2nd Growth Hardwood	**118·4**	**13**	Chestnut-sided Warbler 27·5	Mourning Warbler 23·0	Red-eyed Vireo 13·7	Indigo Bunting 9·1	Song Sparrow 9·1
Open Bog	**111·2**	**8**	Bobolink 37·0	Savannah Sparrow 32·0	Short-billed Marsh Wren 16·8	Redwing 10·1	Swamp Sparrow 8·5
Hardwood Bush	**110·5**	**15**	Red-eyed Vireo 45·0	Oven Bird 15·9	Song Sparrow 7·9	Crow 7·9	Chestnut-sided Warbler 5·2
Roadsides	**105·0**	**32**	Bank Swallow 29·4	Starling 9·9	English Sparrow 9·6	Song Sparrow 8·6	Vesper Sparrow 7·4
Ungrazed Mixed Bush	**95·3**	**21**	Oven Bird 17·7	Red-eyed Vireo 14·5	Chipping Sparrow 11·2	Crow 6·6	Black and White Warbler 6·6
Grazed Mixed Bush	**87**	**21**	Red-eyed Vireo 18·9	Song Sparrow 14·8	Crow 6·7	Chipping Sparrow 6·7	Crested Flycatcher 5·4
Grazed Hardwood Bush	**84·9**	**15**	Red-eyed Vireo 22·4	Robin 12·8	Crow 9·6	Oven Bird 8·0	Crested Flycatcher 4·7
Lowland Conifers	**81·9**	**21**	Song Sparrow 8·5	Cedar Waxwing 5·7	Black and White Warbler 5·7	Black-throated Green Warbler 5·7	Chestnut-sided Warbler 5·7
Clover and Hay	**67·7**	**10**	Savannah Sparrow 23·2	Vesper Sparrow 15·0	Song Sparrow 10·9	Bobolink 8·2	Starling 2·7
Grazed 2nd Growth Hardwood	**64·8**	**11**	Alder Flycatcher 13·0	Chestnut-sided Warbler 8·7	Song Sparrow 8·7	Flicker 4·3	Crow 4·3
Pasture	**59·9**	**36**	Song Sparrow 14·2	Savannah Sparrow 12·9	Vesper Sparrow 5·4	Starling 3·0	Bobolink 2·4
Cultivated Ground and Fallow	**38·6**	**6**	Song Sparrow 12·9	Savannah Sparrow 9·7	Horned Lark 6·4	Killdeer 3·2	Robin 3·2
Grain	**34·7**	**19**	Vesper Sparrow 8·8	Savannah Sparrow 8·5	Song Sparrow 5·7	Kingbird 1·9	Horned Lark 1·6

VI. *Winter Visitors*

Goshawk	Evening Grosbeak
Snowy Owl	Pine Grosbeak
Arctic Three-toed Woodpecker	Redpolled Linnet
Canada Jay	Red Crossbill
Northern Shrike	White-winged Crossbill
Brown-headed Chickadee	Tree Sparrow
	Snow Bunting

SUMMARY

I.	Permanent Residents, Breeding	11 species
II.	Summer Residents, Breeding	93 "
III.	Summer Residents, No Breeding Evidence	9 "
IV.	Irregular, or Rare Summer Visitors	14 "
V.	Migrants	72 "
VI.	Winter Visitors	13 "
		212 species
		104 breeding species

The major interest and values of the bird life of King township centre on the breeding, summer resident, and permanent resident forms. To obtain figures on the populations of these groups a census was made of all the principal ecological types in the township, between May 28th and July 13th, 1937.

Strip Survey

Strips 200 feet wide were run by R. D. Ussher at fixed intervals in the centre of alternate concessions. Distances were measured along the strips by pacing, checked at each line fence or road. Each strip was mapped, all cover types and features such as fences were shown, and all birds seen were noted. By means of these strips an exact census of the birds on 1,270 acres was made. The total population for each cover type was later worked out, and the figures were reduced to breeding pairs per hundred acres.

Table 3 gives a list of the principal types of habitat, with the total bird population and the number of species in each habitat. The names and populations of the five most abundant species in each habitat are also recorded. The complete tally would be too long for this summarized report.

It will be seen from Table 3 that the five habitats showing the highest concentrations of birds are in each case ungrazed, well-watered, wooded

lowlands. It will also be seen that so far as population is concerned the principal birds in the township are of the small song-bird type. As an indication of the approximate actual population of birds in the township the acreage of the various types in Table 3 was estimated, and the total population for the whole township, including the Holland marsh, for eleven species was calculated.

*Estimated Total King Township Population of Eleven Species**

Song Sparrow	8,630	pairs
Bobolink	4,405	"
Red-Eyed Vireo	2,398	"
American Robin	1,380	"
Oven Bird	629	"
†American Crow	483	"
American Goldfinch	481	"
Yellow-shafted Flicker	184	"
Scarlet Tanager	86	"
Great Horned Owl	25	"
Pileated Woodpecker	6	"

Sample Plots

During June and the early part of July, D. A. Ross made a similar census of the wildlife on eight sample plots. These plots were laid out as shown on Map 9, each plot being selected as typical of a particular range of cover type in the township. Each plot was visited several times during the summer. The average size of these plots was 24 acres. They ranged from Plot 8, showing only one type of vegetation, 12 acres of the open Holland marsh, to Plot 6, which included 42 acres of mixed farming land, with an overgrazed and an ungrazed woodlot. The findings of this work substantially agreed with those of Ussher. Since the sample plot work was intended only as a means of comparing the present conditions in particular types with conditions in future years, it is not included in this short report, but is available for reference.

General Survey

Ussher and Ross also made an extensive general survey of the population and breeding grounds of the larger birds, such as ducks, pheasants, partridges, hawks and owls. These spectacular birds are strikingly

*It should be noted that the above estimates are of breeding pairs. The population would, of course, be much greater in most cases at the close of the breeding season, and later further increased by the addition of migrating birds.

†The figure for the Crow population appears low, probably because the females are very wary and unobtrusive when nesting. R. D. Ussher suggests 700-900 pairs as more probable.

absent from the population chart. Most of them are now present in very small numbers. Yet they interest both the sportsmen and the general public more than do the smaller birds. Unless definitely proved to be harmful they should be particularly encouraged in the township. They include, amongst others, the following species:

Pied-billed Grebe—Probably breeds at over half the ponds and lakes.

Green Heron—Most of the lakes and ponds with bush around them support a pair.

American Bittern—Generally distributed and not uncommon.

Red-shouldered Hawk—The most numerous and best distributed hawk in the township. A population of about 25 pairs probable.

Marsh Hawk—About twenty pairs in the township, including at least ten pairs in the Holland marsh.

Black Tern—A colony of at least 50 pairs was found in the Holland marsh, north-east of Bradford.

Black Duck—A breeding population of between 50 and 75 pairs is estimated. There was a heavy concentration of Blacks at one group of small ponds during the summer, reaching a maximum of 90 on August 5th.

Blue-winged Teal—A few pairs breed in the north tip of the Holland swamp, and an occasional pair at small ponds throughout the township.

Ruffed Grouse—The destruction or overgrazing of woodlands, and the draining of cedar swamps, have brought this once common bird to a very low ebb. There are not more than 50 pairs in the township, confined mainly to the woods on the ridge and bordering the marsh.

Common Pheasant—First introduced in 1926, and again on numerous occasions since then. When first introduced these birds flourished. The severe winter of 1933-34 reduced their numbers, and most of those that survived that winter have since been illegally shot. The majority of farmers like to see them, but the birds have little chance for survival against organized hunting drives. There are probably a hundred pairs in the township.

American Woodcock—Seven records were obtained during the summer, but woodcock are uncommon in the township.

Wilson's Snipe—A few remain, confined to the northeast end of the Holland marsh.

Horned Owl—The commonest owl present. An estimate of 25 pairs seems conservative. A good many are shot annually, and this predator is probably not a serious factor in keeping down numbers of other species.

Pileated Woodpecker—It is estimated that there are 5-7 pairs in the area.

*Effects of Reforestation**

The detailed figures of Ussher and Ross showed that with few exceptions the overgrazing of woodlots reduced the numbers of birds per acre, some species, like the Ovenbird, being reduced by as much as 75 per cent. There is no doubt that reforestation would tend to reduce the numbers of a few open land species. The possible effect of changes in the habitats through conservation measures in King township has been estimated by L. L. Snyder, Assistant Director of the Royal Ontario Museum of Zoology, who has examined the bird census results of the year's survey. On the basis of improvements and extension of habitats, his opinion was as follows :

70 per cent of the breeding birds of King township would be aided by planting, reforestation, creation of ponds, and reduction of woodland grazing.

7 per cent would be curtailed or somewhat restricted.

23 per cent would probably show no change. Most of these species use habitats that would be unaffected by conservation measures.

Duck Habitats

An investigation of wild duck habitats in the township was carried out for three weeks in September by W. K. W. Baldwin. From his report on this comparative study of nine bodies of water two general conclusions can be drawn.

The first conclusion is that the preferences of ducks for particular habitats in the township are controlled by a very complex set of factors affecting the available water, cover, food supplies and nesting sites, and no single factor can be said to be critical in the township.

The second conclusion is that since one area far excelled all others examined, as a favourite duck-feeding ground, it may be considered as the ideal habitat for dabbling ducks in a township with limited pond possibilities such as King. (The dabbling or surface-feeding ducks are the only ones likely to make extensive use of the township in the summer.) Using this pond as a model, it is suggested that any body of water in King township, large or small, will attract many wild ducks if the following advantages are provided :

1. A considerable proportion of quiet or stagnant water less than 18 inches deep.
2. Abundant supplies in or around the pond of the following plants, or effective substitutes for them :

*It is assumed that much of the planting would be of hardwood species, since pure coniferous stands in Ontario are invariably low in mammal and bird populations.

Echinochloa Crus-Galli L. Beauv. (Barnyard Grass).

Scirpus pedicellatus Fernald (Woolgrass).

Polygonum amphibium L. (Knotweed).

Polygonum Hydropiper L. (Smartweed).

Lemna minor L and *Spirodela polyrrhiza* (L) Schlied (Duckweeds).

Potamogetons (Pondweeds) and *Radicula* (Watercress) are also recommended.

3. At least two nearby alternative ponds with effective cover for use when the ducks are disturbed. Six possible cover ponds lie within a radius of one mile from the model pond referred to.
4. Freedom from human interference.

For breeding sites the addition of clumps of Willow or Alder, and *Typha* (Cat-tail) would probably be essential, and the presence in the water of large numbers of small molluscs and other invertebrates would help to provide food for the young ducks.

III. Fish

BY J. R. DYMOND AND W. J. K. HARKNESS

The waters of King township consist largely of headwater streams rising in the hills which cut across the centre of the township and a series of small lakes occupying the depressions between the numerous hills.

There are few waters large enough to support the larger species and hence the fish fauna is chiefly composed of the smaller forms. There is no evidence that the township ever did support any considerable population of the larger game species, although the shrinkage of the permanently running streams from a length of two hundred miles to twenty-five must have materially reduced even the small population once present.

The lakes differ widely in their character so far as fish life is concerned. Some such as Eversley, Marie and Hackett (Nancy) support a population of large-mouth black bass (green bass), pumpkin seed sunfish, perch and various minnows and other small species. Kelly lake has a deep layer of decaying vegetation on the bottom and the fish inhabiting it are of species characteristic of acid, boggy water including red-bellied dace, fine-scaled dace and fat-head minnows. Loch Erne and Hall's lake are intermediate between the two types just mentioned. Loch Erne is more like Kelly lake, the fathead minnow being its most abundant species; while Hall's lake is more like Eversley, Marie and Hackett, the muskoka minnow being its dominant species.

The maximum depths found in some of the lakes were as follows: Hackett (Nancy), 62 feet; Eversley, 65 feet; Kelly, 40 feet. A series of temperatures taken from the top to bottom of Hackett lake on June 17, 1937, gave the following results: Surface, 72°F.; 5 feet, 66°F.; 10 feet, 58°F.; 15 feet, 47°F.; 20 feet, 44°F.; 25 feet, 42°F.; 30 feet, 42°F.; 40 feet, 41°F.; 50 feet, 40°F.; 62 feet, 39°F.

The temperature of the east branch of the Humber between the sixth and eighth lines on August 16th, 1937, ranged from 71°F. to 73°F.

In our studies collections of fish were made at sixteen stream stations, in six lakes and in the drainage canal.

Speckled trout (*Salvelinus fontinalis*) are found in only three or four streams in King township, so far as known. They are native to Kehoe's creek, a tributary of the Humber river rising in a cedar swamp. This is a clear, cold-water stream, the temperature of which on June 25, 1937, was 53°F. On the same day other tributaries were 60°F. and higher. The largest trout reported from this stream was 17 inches in length. The other fish taken in the same stream were common suckers, creek chub and miller's thumb (*Cottus bairdii bairdii*).

Until five years ago trout were found in Kettleby creek below Kettleby but none are to be found in this section of the stream at the present time. Trout were introduced about 1925 in the west branch of this stream at lot 24, concession 4, where a thousand fry were planted. Due to the removal of the screen placed in the stream below the point of introduction the trout spread down stream. It has not been determined with certainty whether trout occurred in this stream in the early days but it seems clear that none occurred in it for many years before this introduction.

Speckled trout formerly occurred in a stream flowing into Eversley lake, and it is likely that under original conditions they were found in other similar brooks.

Brown trout (*Salmo fario*) have been planted in the Humber above the dam at Woodbridge in several years beginning in 1932. Whether any of these have penetrated as far as King we do not know. The following number of fingerlings were planted in the years indicated: 1932, 15,000; 1933, 10,000; 1934, 5,000. In 1935 and 1937 yearlings were planted, 550 in 1935 and 3,000 in 1937.

Carp (*Cyprinus carpio*) are found in the Holland river and canal, which they have entered from lake Simcoe. They were also planted in Eversley lake about 1905 and still occur there.

The commonest fishes found in the streams of the township are common suckers, creek chub, creek shiners and black-nosed dace.

The suckers (*Catostomus commersonii*) found in our work were largely young of the year, and others up to a length of six inches. They were

common in the Humber and at all stations examined on its east branch. They were not taken so commonly in tributaries of the Holland river. The largest specimen (12 inches) was found in a cold stream in which speckled trout occur. Adults undoubtedly resort to the smaller streams in spring to spawn. The species was taken at eleven stations. A smaller species, the hog sucker (*Hypentelium nigricans*), which is usually found over a stony or gravelly bottom, was taken at only two stations, one in a typical habitat in a tributary of the Holland river and in an oxbow cut-off from the Humber.

The creek chub (*Semotilus atromaculatus*) is the most generally distributed fish in the creeks of the township. It was taken at fifteen stations, that is, at every creek station but one where collections were made.

The black-nosed dace (*Rhinichthys atratulus*) is common, being found wherever there is a current over a gravelly or stony bottom. It was taken at eleven stations. The long-nosed dace (*Rhinichthys cataractae*) was found in only two situations, in both cases in rather swift, clear water over gravelly bottoms.

The creek shiner (*Notropis cornutus*) is the most abundant fish in the larger streams. Although found at fewer (nine) stations than the common sucker, creek chub and black-nosed dace, this species occurred in some situations in very large numbers.

Other minnows of less frequent occurrence in the waters of King township include the muskoka minnow (*Notropis heterolepis*), a lake or stagnant species found in Nancy lake, Hall's lake, the canal and in an oxbow cut-off from the Humber river; black-chin minnow (*Notropis heterodon*) in Hall's lake and Schomberg river; blunt-nosed minnow (*Hyborhynchus notatus*); red-sided dace (*Clinostomus elongatus*); golden shiner (*Notemigonus crysoleucas*) and five small species characteristic of stagnant waters, especially those of a boggy nature. These include the brassy minnow (*Hybognathus hankinsoni*), fat-head minnow (*Pimephales promelas*), red-bellied dace (*Chrosomus eos*), fine-scaled dace (*Pfrille neogaeus*), and northern dace (*Margariscus margarita*).

The fat-head minnow is very abundant in loch Erne and fairly abundant in Kelly lake. The red-bellied dace is abundant in Kelly lake, and the fine-scaled dace moderately so there. These all appear to be rare elsewhere. The brassy minnow was found only in the Holland river, and the northern dace only in Kettleby creek.

Common catfish (*Ameiurus nebulosus*) or bullhead is found in Eversley, Marie and Kelly lakes, in loch Erne and in the canal.

Pike (*Esox lucius*) occur in the Holland river and canal but not so far as known in the lakes or small streams.

Maskinonge (*Esox masquinongy*) still run into the Holland river in

spring to spawn, although most of their original spawning grounds have been destroyed by the drainage of the marsh. Seven creeks flowing into the Holland or Schomberg river from the south in King township were once visited by maskinonge at spawning time. From east to west these creeks were Catfish, McClure's, Banks', Hay, Gordon's, King (Kettleby creek), and Broad. The flooded marsh surrounding the creeks are said to have provided ideal spawning grounds. Mr. Collins of Bradford reports having seen spawning lunge half a mile from the river, at high water. Most of these creeks have been eliminated by the drainage of the marsh.

Killifish (*Fundulus diaphanus menona*). This member of the top-minnow family was found only in Hall's lake. The fishes of this family are noted for their destruction of mosquito larvae.

Four species of darters occur. These are all small fish seldom exceeding a length of two inches. As a group they are found in clear water running over gravelly or stony bottoms. They lie hidden among the stones, darting quickly from one hiding place to another when disturbed. The rainbow darter (*Poecilichthys coeruleus*) is the dominant species in the streams of King Township. The Johnny darter (*Boleosoma nigrum*) is moderately common, while the fan-tail darter (*Catonotus flabellaris*), and Iowa darter (*Poecilichthys exilis*) are least common. The latter prefers standing waters with muddy bottoms and so is characteristic of lakes. It was found in Hackett and Hall's lakes and loch Erne.

Large-mouth black bass or green bass (*Aplites salmoides*) is found, probably native, in Hackett (Nancy), Eversley and Marie lakes and in the canal. In Eversley lake a specimen weighing 7¼ pounds has been taken.

Four species of the sunfish sub-family are found. The pumpkin seed (*Eupomotis gibbosus*) and rock bass (*Ambloplites rupestris*) are moderately common. They live in the deeper pools of the streams and in lakes. Large rock bass are said to have occurred formerly in the Holland river. The bluegill (*Helioperca incisor*) was found only in Hackett (Nancy) lake.

The yellow perch (*Perca flavescens*) appears to be rather uncommon in Hackett (Nancy), Eversley and Hall's lakes.

The yellow pickerel (*Stizostedion vitreum*) is said to occur in the canal.

The miller's thumb (*Cottus bairdii bairdii*) is a cool water creek species, commonly found associated with the speckled trout. It was most abundant in Kehoe's creek, a cold water creek containing a population of speckled trout. It was also found in some numbers in a small creek at Pottageville, although so far as known no trout occur in this stream. Occasional specimens were also found in other streams.

The brook stickleback (*Eucalia inconstans*) is found in Hackett (Nancy) and Hall's lakes. It prefers stagnant water with a muddy bottom.

IV. Amphibians and Reptiles

For the sake of completeness a list of amphibians and reptiles known to occur in King township is included. This list is based on the 1929 report of E. B. S. Logier, who mentions that "future collecting will doubtless add other species to it".

Amphibians

Green Newt
Jefferson's Salamander
Spotted Salamander
Red-backed Salamander
American Toad
Swamp Tree-frog
Spring Peeper
Tree Toad
Green Frog
Pickerel Frog
Leopard Frog
Mink Frog
Wood Frog

Reptiles

Smooth Green Snake
Milk Snake
DeKay's Snake
Redbellied Snake
Ribbon Snake
Ringnecked Snake
Garter Snake
Snapping Turtle
Painted Turtle

V. Non-Native Game and Fur

For most of the larger native woodland species, King township, even under intensive conservation measures, can never again be a habitat capable of yielding really high populations.

It can hardly be hoped that trapping will again become an important activity in the township, though the existence of many marshes and ponds gives a chance to greatly increase the population of mink and muskrat. Occasional closed seasons, together with an increase in the woodlands surrounding lakes and streams, and a rise in the ground water level, would probably achieve this effect. It is unlikely that either restocking with former fur-bearers of the township or introduction of non-native species would be successful.

The European hare, which has recently spread into the township, is there to stay. Hunting will certainly keep its numbers down to a reasonable figure. At the present time it appears doubtful whether the Common Pheasant can survive the combined effects of predators, severe winters and illegal shooting. In King township it is undoubtedly on the extreme northern edge of its possible range. The introduction of other new species has been considered by many in the township, since apart from the Ruffed Grouse, not well suited to the present open habitat, there is little other game-bird life left. The danger of introduction need hardly be stressed. The Starling and English Sparrow in King are suffi-

cient evidence of this. On the other hand, the strenuous efforts now being made in Ohio for the conservation of a large population of Common Pheasant and Bob-white Quail, which were respectively unknown and very scarce in the state at the time of first settlement, show that neither introduction nor spread of range need necessarily be harmful. One experiment is now being made in King township with the Chukar Partridge, and further information on this species will soon be available.

VI. Hunting

The opinions of 279 farmers were asked on hunting. Only one farmer objected to the shooting of the European hare. None objected to the shooting of groundhogs. But 155, or 56 per cent of those questioned, disliked the hunters and their methods. Seventy-five farmers, or 27 per cent, approved of hunters. Forty-nine farmers, or 17 per cent, were uninterested.

It is estimated that only about 25 per cent of the farmers in King township do any shooting themselves.

The main reasons for the dislike of hunters by farmers are :

Damage to wire and rail fences.
Shooting of pheasants which are protected in King township.
Dangerous shooting.
Intentional shooting of livestock.
Opening and leaving open of closed gates.
The overbearing manners of hunters.

The very high percentage of farmers of British origin in King township, and the fact that the majority of those hunting in King township from Toronto are of other national origin, may be an important factor in this matter.

PRESENT TRENDS

It is highly improbable that there will be any improvement in the conditions of soils, waters and wildlife in King township if no special effort is made to improve them. Present trends may be summarized as follows :

Woodlands. Land is still being cleared entirely of tree growth in the Holland valley and several other minor areas in the township. The fact that more than 50 per cent of the standing cordwood in the township is now mature or almost mature (being of second growth origin following the first cutting) leads to the conclusion that the average cut per annum will exceed the average growth per annum for some time to come.

An actual shortage of fuel wood is already occurring in the township. This shortage is not yet very noticeable because of the large number of

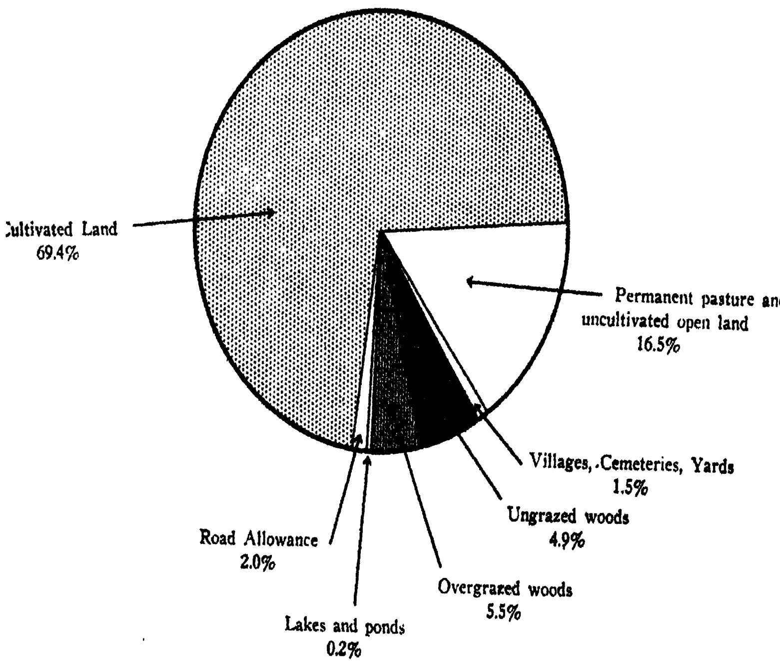
farmers who are now using old fence rails and posts as fuel. The new fences are of wire. As each overgrazed woodlot is cut down, grass and not woodland takes its place.

Water. It is known that the water reserves in the township are now very low. It can be forecasted that further depletion of woodlots will lead to a further lowering of the ground water, with consequent drying of springs and streams.

Erosion. Both sheet and gully erosion are now very common in the township. Some of the more seriously eroded areas are shown on Map 6.

ERODED GULLY

Under the King Township plan, this gully could be controlled and reclaimed, as a demonstration which farmers would observe and follow.



LAND USE IN KING TOWNSHIP, ONTARIO,
in 1938

(exclusive of the Holland Marsh area.)

The more spectacular form of erosion is the formation of gullies, but economically it is the loss of topsoil which has caused the abandoning of many farm lands which should never have been cleared. The major areas of cleared land now uncultivated are shown on Map 7. A close correlation between the location of these lands and the location of the Kame area can be seen. All of these lands are either too sandy or too steep to give any hope of sustained yield under cultivation. They are admirably adapted to the growing of trees.

Animal Life. The number of persons hunting in King township appears to be increasing. The present practice of organized hunting drives across large areas of land leaves no chance for the escape of game. Further reduction in woodlands and water reserves will certainly further reduce the remaining game and other wild animal life in the township.

Land Use. The present trend in land use in King township is towards an increase in city-owned farms. Most of these farms give an erroneous impression of profitable agriculture. Few of them are worked at a profit. As one farmer remarked, referring to a neighbouring, city-owned farm, he "would like to make as much as is lost every year on that farm". Since many of the farmers hope eventually to sell their farms for country estates, the price of farms in general over the area is far above the proper capital value of the land based on soil rent. The limiting factor in the trend towards city-owned farms is the presence of streams or lakes, woods, and rolling land on the farms. Most of the land of this type is already in the hands of city owners.

Many of these farms are already "posted" against outside hunting and fishing, and most of their owners are much interested in reforestation. There is no doubt that this tendency will help to improve both the soil and the wildlife of the township, but as the number of farms of this specialized type available in the township is strictly limited, no large scale improvement of the land can be expected from this source.

RECOMMENDATIONS

The present fully effective woodlands cover only 4.9 per cent of the township, exclusive of the Holland marsh area. The release of the present grazed woods from grazing would increase the effective woodlands to 10.4 per cent. A few of these overgrazed woodlots would have to be replanted in part. A further addition of 4,250 acres of plantations would bring the total woodlands to 15.6 per cent of the whole area. This may not be the ideal percentage, but it is a practical goal at which to aim. Map 8 shows a preliminary plan of the township covered in this manner.

It should be noted that this plan involves the planting of only 5.2 per cent of the township. More than 2,500 acres of former farms are now cleared but no longer cultivated. (Map 7.) On every farm there are two or three acres of waste land. It is estimated that there are at least 17,000 acres of land not adapted to profitable farming in the township, exclusive of the Holland marsh. The project, therefore, appears practicable, given the co-operation of the farmers.

During the course of the 1937 survey, more than 700 acres were made available by farmers for immediate planting of trees. It is not feasible to plant such an area in a single year.

The recommended improvement work for the first year is shown on Map 9. A summary of the suggested work follows :

1. *Plantations.* Four hundred acres, selected from the 700 acres of available planting land, can be reforested. A small part of this planting would take the form of shelter belts. The number of seedlings required for this planting is indicated in Table 4.

2. *Nurseries.* Two or three small transplant nurseries can be set up. These are essential for heeling in seedlings, for hardening seedlings for particular soils, and for keeping some seedlings available for filling in blanks. Land has already been made available for two of these.

3. *Demonstration Woodlots.* During 1937, five demonstration woodlots were added by the Provincial Forestry Branch to the two already in the township. It is recommended that two or three additional woodlots be added to the number, in strategic parts of the township.

4. *Dams.* It is recommended that several small dams, located as shown on Map 9, be placed near the headwaters of certain streams, and that the Schomberg and Kettleby dams be repaired. The spillways of these last two dams were of insufficient capacity and the cut-off walls too short. With wider spillways* and longer cut-off walls these dams will be safe while still capable of storing many acre-feet of water.

These dams will serve to reduce floods and soil erosion. They will make a constant supply of water for stream improvement. They will aid in raising the ground water level, and their ponds will improve the conditions for ducks and other wildlife.

5. *School Yard Plantings.* Seven school yards in the township have few or no trees. In these the children can help with planting shelterbelts

*Schomberg drainage area: 11 sq. miles. Suggested spillway capacity to control discharge in time of super-flood: 3,500 c.f.s.

Kettleby drainage area: 8 sq. miles. Suggested spillway capacity: 2,500 c.f.s.

TABLE 4

Transplants Required for Planting 400 Acres in King Township

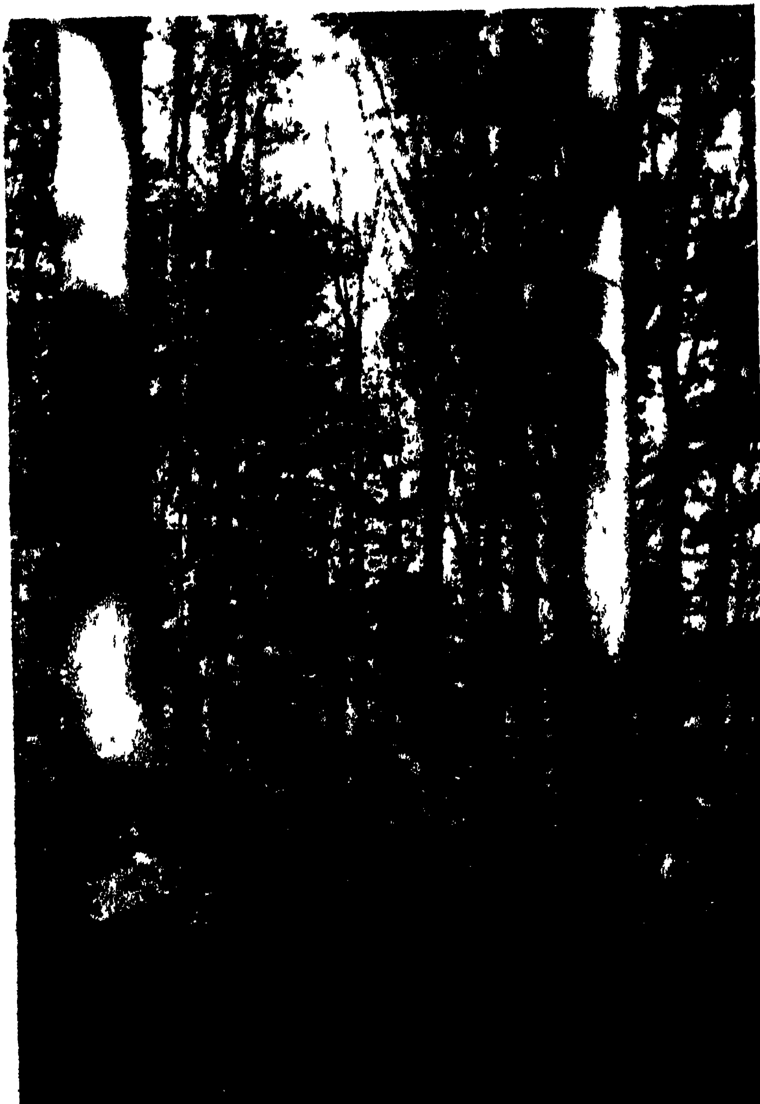
Tree Species	Wet Clay	Level Clay	Loam	Light Land	Clay Hills	River Banks	Wind-breaks	Total
White Pine		5,000	10,000	10,000				25,000
Red Pine			10,000	90,000				100,000
Jack Pine				30,000	5,000			35,000
Scotch Pine		5,000	5,000	90,000	10,000			110,000
European Larch	1,000				10,000			11,000
White Spruce	2,000	10,000			10,000		200	22,200
White Cedar	3,000			10,000		1,000		14,000
Walnut		2,000	10,000					12,000
Butternut			2,000					2,000
White Elm	3,000	5,000			20,000			28,000
White Ash		5,000	15,000	15,000	20,000			55,000
Soft Maple	2,000	1,000	15,000					18,000
Hard Maple		1,000	5,000		10,000			16,000
Red Oak		2,000		15,000				17,000
Carolina Poplar (cuttings)					10,000	2,000		12,000
Carolina Poplar (rooted)				1,000	1,000			2,000
White Willow	1,000					2,000		3,000
Norway Spruce							800	800
Totals	12,000	36,000	72,000	261,000	96,000	5,000	1,000	483,000

Total—483,000

and small plots of trees. These will serve not only to improve the amenities of the schools, but also as education in reforestation.

6. *Test Wells.* To record movements in the level of the ground water, regular measurements of the height of the water in a few unused wells are necessary. One such well has already been selected, and some measurements taken. It is recommended that several other wells be selected and used for this purpose.

7. *Erosion Control.* One of the worst erosion gullies in the township overlooks a public road in the centre of the township. It is suggested that this gully be controlled and reclaimed, as a demonstration which farmers can observe and follow. The cutting power of the water can be reduced by inexpensive check dams across the gully. Dense plantings of Carolina Poplar and Black Locust will bind the eroding clay banks. The Black Locust, like Alfalfa, fixes nitrogen from the air, and will prepare the soil for the planting of more valuable species later.



A WOODLOT RELEASED FROM GRAZING

Formerly cut over and lightly grazed, this woodlot is now fenced from cattle Seedlings of Sugar Maple and Beech now cover the ground, and future crops of wood are assured.

The complete absence of saplings in the woodlot is due to former grazing.

CONTOUR FURROWS

Land well prepared for experimental plantations

Farm of W C Harris, King township, Ontario

8. *Wildlife Census.* The census made on the sample plots shown on Map 9 can be continued when the time is available, as a measure of the effects which planting and other improvements may produce.

9. *Co-operative Wildlife Management.* The owners of the properties marked under this heading on Map 9, are co-operating in making experimental plantings for the improvement of the wildlife of the township. Besides reforestation, some food plants will be set out. Many pheasants and other birds were attracted to the area by food set out during the past winter. This work will be continued during 1938.

10. *Labour required to complete the first year's work.* It is estimated that a camp of twenty-eight men, exclusive of forestry or engineering staff, could complete the first year's work of the project.

FUTURE PLANS

It has already been noted that more than 700 acres of land was made available by farmers for immediate planting under the first year's work of the project. The suggested planting of 400 acres of land in the first year would leave 300 acres of land available for the second year's planting. Already since the field work of the survey was completed, 100 acres of additional land have been offered. This means that the full second year's planting land is also now available. It is beyond doubt that as planting takes place many new areas of land will be made available to the project. The project, therefore, will not fail for lack of land.

Several woodlots will no longer be overgrazed, as a result of the 1937 interviews with farmers, but a continued drive of publicity for conservation is necessary. The seven demonstration woodlots will help in this work, and the prominent marking of any lands planted under the project would be of great value. These forms of education, together with the suggested school-yard plantings, should eventually result in the release from grazing of the majority of the overgrazed woodlots.

Once the value of soil control is fully appreciated, more intensive methods of conservation will gradually come into use. These methods will include the withdrawal of all steep slopes from cultivation, and their use as pasture or woodland; the adoption on eroding lands of the strip system of cultivation, and the use of grassed waterways; and the planting of all stream banks with trees.

ACKNOWLEDGEMENTS

The work of the Advisory Board and staff of the survey was greatly simplified by the co-operation received from many people, including, amongst others, the Reeve and Council of King Township, the committee

of representative citizens of the township, several members of the staff of the Provincial Forestry Branch in Toronto and many staff members of the Royal Ontario Museum of Zoology.

The survey was particularly indebted for advice and help to I. C. Marritt (provincial woodlots expert), L. L. Snyder, Assistant Director of the Royal Ontario Museum of Zoology, and W. C. Harris, of King Creek Farm. Mr. Harris, an enthusiastic supporter of the project, generously provided headquarters for the survey and space for experimental tree plantings.

The survey is also indebted to J. P. Oughton, of the staff of the Royal Ontario Museum of Zoology, for a list of forty-eight species of molluscs, compiled from collections which he made in King township. The collection and list are available for reference.

SUMMARY

A year's survey was made, in 1937-1938, of the natural resources of King township, to analyse the present conditions and to make recommendations for their improvement.

Methods

An aerial survey of the township was made. All farmers were interviewed, and information recorded covering soil, water, wildlife, vegetation and land available for tree-planting.

All woodlots were examined. Intensive studies were made of the habitats, population and density of birds and other wildlife. Representative samples of fish and invertebrate fauna were taken on all the permanent streams in the township.

Present Conditions

The effective woodlands in the township are now reduced to 4.9 per cent of the total area. This is inadequate for the preservation of soil, water and wildlife. The ground and surface water are greatly reduced. The 200 miles of permanent streams which formerly ran in the township are now reduced to less than 30 miles. Two hundred and sixty-four wells no longer give a permanent supply of water. Little is left of the original wildlife of the township. A few species have increased since settlement, but a lack of woods for food and shelter have greatly reduced most of the more interesting and useful ones. Erosion has removed much of the topsoil, and some farms have been abandoned.

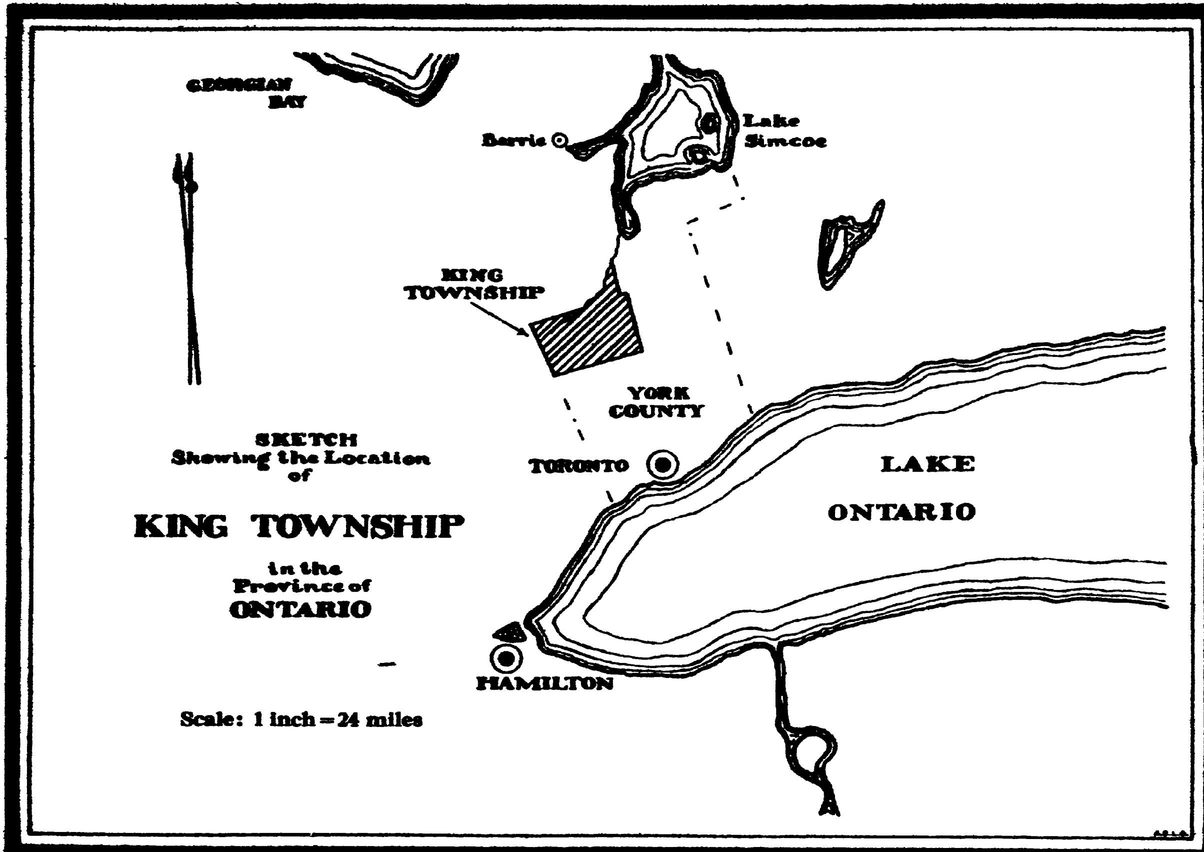
The conditions of the natural resources in King township are now unstable and the present trend is towards poorer soils and a further

impoverishment of the woods, water reserves and wildlife. Definite action is needed to prevent further deterioration and to restore the township to stable conditions.

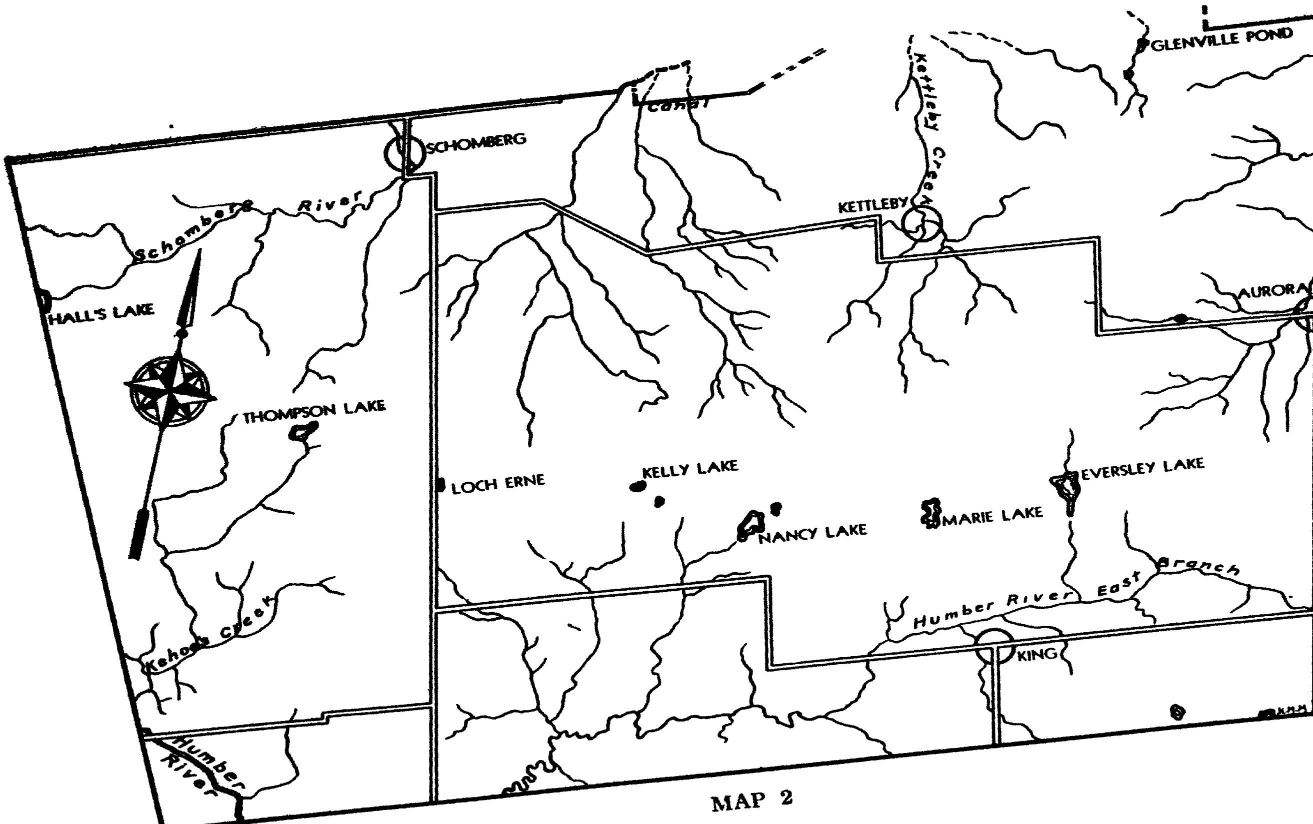
Improvement Plan

A plan has been prepared for the improvement of the township as a demonstration that may be followed in other similar areas. The first year's work on this improvement plan involves, amongst other things :

1. Planting of 400 acres of waste lands with 480,000 tree seedlings. Seedlings for forest planting are provided free by the Provincial Government of Ontario.
2. Establishment of several test wells.
3. Building of several small dams and repairs to two existing ones.
4. Establishment of two or three small transplant nurseries.
5. Education in conservation by planting of school-yard plots, and other methods.
6. An erosion control demonstration.
7. A demonstration of co-operative wildlife management.


GEORGIAN BAY
Barrie
Lake Simcoe
KING TOWNSHIP
YORK COUNTY
TORONTO
LAKE ONTARIO
HAMILTON
SKETCH
Showing the Location
of
KING TOWNSHIP
in the
Province of
ONTARIO
Scale: 1 inch = 24 miles

MAP 1


GLENVILLE POND
canal
SCHOMBERG
Kettleby Creek
KETTLEBY
AURORA
Schomberg River
HALL'S LAKE
THOMPSON LAKE
LOCH ERNE
KELLY LAKE
NANCY LAKE
MARIE LAKE
EVERSLEY LAKE
East Branch
Humber River
KING
Kehoe's Creek
Humber River

MAP 2

MAP 3

SOILS

MAP 4

1840 CONDITIONS

MAP 5

WOODLOTS

MAP 6

WATER

STUDIES OF WATER-FOWL IN BRITISH COLUMBIA

No. 9

Barrow's Golden-eye, American Golden-eye

By J. A. Munro
Chief Federal Migratory Bird Officer for British Columbia

Introduction

The present paper deals with the distribution, life-history, and economic status in British Columbia, of the Barrow's Golden-eye, *Glaucionetta islandica* (Gmelin) and the American Golden-eye, *Glaucionetta clangula americana* (Bonaparte).

Field observations of golden-eyes have been carried on at intervals since 1911, the earlier work comprising chiefly studies of distribution and general life-history. Since 1930 the investigation has included the examination of the stomach contents of specimens and more recently an attempt has been made to obtain quantitative data in respect to the numbers comprising the summer population, the survival of young, feeding habits and the relation of the species to other animals. In connection with the analyses of stomach contents, it was realized that this method by itself was of limited value and that a reasonably correct interpretation of such data is possible only when supported by field observations. Stomach analyses reflect what the bird has eaten but give little indication of how such food has been obtained. The author feels that the greatest value of analyses is in checking or supplementing studies of the feeding habits of the bird in its environment. Furthermore it is believed that a small number of specimens taken under known circumstances, in a habitat which is being studied, is of greater value than a large general collection about whose origin nothing is known except the date and place of capture. The stomachs used in this study were collected either personally by the author or, with a few exceptions, collected at certain places at certain times under his direction.

The study of the food in the digestive tracts of most of the golden-eyes examined was conducted as a joint undertaking by Dr. W. A. Clemens, Director of the Pacific Biological Station, and the author. The material was examined with a binocular microscope and all items were checked by each investigator. Dr. Clemens also assisted the author in the preparation of this paper. Grateful acknowledgment is made to him for this co-operation and to the Fisheries Research Board of Canada for the use of laboratory facilities.

The author wishes to express appreciation of the assistance given by the United States Bureau of Biological Survey in making available additional analyses of specimens collected by the author during the period 1911 to 1917; to the National Museum of Canada for the loan of study skins; to the Dominion Department of Fisheries in supplying specimens from the Cowichan river; to Mr. R. A. Cumming, Dr. C. N. Bastin, Dr. M. Y. Williams, Mr. P. M. Martin and Mr. Dennis Ashby for similar favours; to Mr. W. N. Newcombe and Dr. Josephine F. L. Carl for the identification of certain mollusks and crustaceans, and to Dr. Ian McTaggart Cowan, Mr. H. M. Laing and Mr. T. E. Randall for permission to use unpublished records. Special thanks are due Mr. L. Crowe for co-operating in the study of the Barrow's Golden-eye population at Paul lake.

DESCRIPTION OF SPECIES

Golden-eyes are medium-sized, rather heavily built diving ducks with relatively short necks and large heads. The males average twenty inches in length and the females are somewhat smaller. The adult males of both species are predominantly black and white; the American Golden-eye has a greenish coloured head with an oval white spot on each cheek at the base of the bill, while Barrow's Golden-eye has a violet-coloured head and a crescentic white patch at the base of the bill. The latter species has less white on the back and the flank plumage has more black on the feather margins as compared with the same area on the American Golden-eye so that in general appearance Barrow's Golden-eye is the blacker of the two. This is a better distinction in the field than is the difference in head coloration and shape of white cheek patches, which cannot readily be seen at all times. In both species the bill of the male is black, the feet chrome and the iris clear yellow.

The adult females, yearling females and yearling males of the two species are of similar coloration with brown heads (varying in shade with age and wear), dark grey backs and flanks (feathers dusky grey margined with lighter grey), grey chest, white neck and white underparts. Slight differences in colour due to age and specific differences, while noticeable in museum specimens, are not usually apparent in life. For the period from February to May the bill of the adult female Barrow's Golden-eye is cadmium yellow to orange usually freckled with brown on the basal half, while that of the adult female American Golden-eye is dark olive brown sometimes suffused with yellow at the base or on the terminal third. This colour distinction disappears after the breeding season. The bills of young females of both species are dark olive brown. The iris is clear yellow in the adult female, greenish yellow in yearling females and amber in the young.

Young females of both species in first plumage resemble the older females in colour and pattern but the chest band and flanks are usually more fawn than grey and the neck is not white as in the adult female but of the same brown colour as the head, or a few shades lighter. They continue a slow moult through the year and by the following spring are usually indistinguishable from the adult female except for the difference in bill coloration.

Young male golden-eyes have the same colour formula as the females but may be recognized as males by their larger size. The fawn, grey, white and brown coloration of the first plumage is held until early in the first winter, after which the fawn-coloured contour feathers are gradually replaced by grey, the neck gradually becomes white and a few white feathers appear on that area at the base of the bill which later will develop as a white patch on the brown head. By the following spring the white area may be quite conspicuous on some individuals. The coloration of the iris follows the same development as in the females.

The downy young of the two species are indistinguishable except for differences in shape of bill and in the trachea, which are referred to later. The down is blackish above (with small white area on wing and rump) and white below, the line of demarcation crossing the cheek below the eye so that the appearance on the water is that of a blackish bird with a black and white head. The same general arrangement of black and white is found in the downy young of Bufflehead, *Charitonetta albeola*. In large, downy young the upper surface may be faded to light brown before the first dorsal feathers appear.

For some time after the downy stage has been replaced by the first plumage, filaments of white down continue on the cheeks. Thus young birds half or three-quarters grown appear to have definite white cheek patches when viewed at a distance.

A variable but generally appreciable difference between the two species of whatever age or sex is to be found in the shape of the bill (fig. 1). In Barrow's Golden-eye the bill is shorter and narrows more deeply towards the tip as compared with that of the American Golden-eye. The nail (the process at the end of the bill) is wider at the front, projects farther over and is slightly raised above the bill, so as to form a noticeable hump. In the American Golden-eye the nail is narrower with much individual variation. Sometimes it is flush with the surface of the bill and for that reason not conspicuous. There is reason to believe that this distinction does not always hold good, as will be explained later, but in the case of the young as well as the mature males there is another anatomic character that is apparently infallible. This is a difference in the shape of the trachea (fig. 2), which in Barrow's Golden-eye shows a gradual swelling

and attenuation and in the American Golden-eye is provided with a circular, centrally depressed enlargement.

The distinctive characters of the *islandica* bill hold good in all adults, yearlings, and all Okanagan-taken juveniles, recently examined by the author (5 ad. ♂, 3 ad. ♀, 6 yearling ♀, 3♂, 2♀, young of the year). They hold good in only one of ten young birds from the Cariboo region. In this series of seven males and three females, from two to three months old, one female has the tapering bill with wide, raised and conspicuous nail characteristic of *islandica*. The remainder have wide, straight bills with narrow, depressed inconspicuous nail and cannot be distinguished from *americana* of comparable age on the basis of any external character known to the author. Nevertheless the males are identified as *islandica* on the basis of the diagnostic trachea, the two females on presumptive evidence as they belonged to broods from which identifiable males were collected. So far as is known *americana* does not breed in the Cariboo. Three yearlings and one adult female specimen from this region have the typical *islandica* bill.

From the foregoing it seems evident that young male golden-eyes can always be identified specifically by the shape of the trachea but in the case of young females the identification of some individuals is impossible on the basis of any known characterization.

BARROW'S GOLDEN-EYE, *GLAUCIONETTA ISLANDICA*

LIFE-HISTORY

Distribution

An eastern population of Barrow's Golden-eye breeds in Iceland, Greenland and Labrador, and a western population in southern Alaska, British Columbia and the Rocky Mountain states south to northeastern California (fig. 3). The intervening territory from eastern Quebec west to the Rocky Mountains is not occupied by this species.

Dr. H. F. Lewis recently brought together the best available information concerning the distribution of the species in eastern North America but, because reliable information is scarce, considers the result unsatisfactory. The following four paragraphs have been abstracted from a personal communication on the subject.

The winter range is considered to be well stated by Bent (1935) as follows: From the Gulf of St. Lawrence southward along the coast regularly to eastern Maine (Washington County), rarely to southern New England and as a straggler beyond.

Concerning the breeding range, Dr. Lewis found nothing to add to the statement by John C. Phillips (1925) that this duck breeds in south-

western Greenland and on the extreme northeastern part of the Labrador peninsula probably as far south along the Atlantic coast as Davis inlet, or even farther.

It is quite common during spring and fall migrations at Metis, Quebec, on the south shore of the lower part of the St. Lawrence estuary, and R. W. Tufts considers it to be a fairly common winter visitant to suitable localities throughout the Maritime Provinces.

Mr. James L. Baillie states that the only definite Ontario record concerns a drake taken at Toronto on April 18, 1885, and recorded by Seton (1885). Nevertheless it is necessary to consider a statement by Dr. D. G. Elliott, 1898, as quoted by Bent (*loc. cit.*), as follows: "I have found it at times quite numerous on the St. Lawrence near Ogdensburg, and have killed a goodly number there over decoys, and some specimens, procured on these occasions, are now in the Museum of Natural History in New York". This is an indication of occurrence in Ontario as Ogdensburg is just across the river from Prescott, Ontario, about a mile away.

In British Columbia the species breeds throughout the interior, more commonly in the Dry Belt than elsewhere, and has been reported from various lakes west of the Cascade Mountains where evidently the nesting populations are smaller than those of the interior.

Racey (1926) in June, 1924, found from one to three females, believed to be nesting, on each of several lakes including Alpha (1 mile), Alta (1½ miles), Green (2¾ miles), tributary to the Cheakamus or Lillooet rivers. Alta lake, near the middle of this lake chain, is thirty-eight miles northeast of the head of Howe sound, at an altitude of 2,197 feet. This author in a personal communication reports that golden-eyes (originally recorded in The Auk as *americana* but subsequently identified as *islandica*) breed regularly on all the small lakes of this region, where he observed broods of young at different times.

H. M. Laing reports in a personal letter that on Owikeno lake at the head of Rivers inlet, eight young golden-eyes able to fly, and other young not so far advanced, were seen on August 19, 1937. On August 28, 1937, a brood of seven young, perhaps the same encountered on the earlier date, was recorded. Specimens were not collected and there is some doubt as to the specific identity of this population.

Several reported breeding records from Vancouver island (Forbidden Plateau and Upper Campbell lake) and Graham island are not supported by the evidence of specimens. The species is rare on the Queen Charlotte islands at any season.

Dr. Ian McTaggart Cowan states: "In 1936 when we worked the Ootsa lake district we found golden-eye scarce. This is probably accounted for by the nature of the lakes themselves. They have steep,

rocky shores, calculated to produce little food suitable to the golden-eye. Between Eutsuk lake and Whitesail lake on the Tahtsa and Whitesail rivers on July 14th we saw two golden-eye. On July 16th on Eutsuk lake we saw two more, these four being all those seen in over two hundred miles of travel on the lakes named. Tom McKinley, a trapper on Pondosy lake, reported to me that a golden-eye nests near his cabin every year." (Personal communication April 4, 1938.)

M. Y. Williams (1923) records the presence of a small population on the Fort Nelson river, June 11 to June 16, 1922.

Swarth (1937) lists it as a summer resident "the most abundant and most generally distributed species of duck" in the Atlin region, but includes no population counts. The earliest date of arrival in spring (1933-35) was April 23 and it was last recorded in autumn on October 21 (1931). This author (1922) also records it from various points on the Stikine river near Telegraph creek and on Sawmill lake; it is evident from his report that in none of these places was the species abundant.

The species is reported from the base of the Alaska peninsula by Osgood (1904), who states, "One was seen on the Nogheling river July 20, and one was killed there some days later; another was shot by W. L. Fleming on a small pond near the head of Lake Clark, July 28. Several immature birds were killed at the mouth of the Chulitna river, August 4. Rather common at intervals along the Chulitna river, August 12 to 17; generally seen in family parties of 6 to 10. Near Swan lake a flock of about 15 was seen feeding on a shallow lake in company with a flock of 10 swans. Seen almost daily in pairs or small flocks along the Malchatna and upper Nushagak, September 3 to 6".

The centre of the densest nesting population is the dry belt region of the Okanagan, Nicola, Kamloops, Chilcotin and Cariboo districts. The last name is used to identify the area lying between the Fraser river and the North Thompson river from latitude 51 to latitude 52. Briefly it can be said that the greater part of the population nests in the interior and winters on the coast. The number of wintering records for the interior is small. Details of the seasonal movements, which are complex and not thoroughly understood, are discussed in the following section.

Seasonal Movements and Numerical Status

The summer home of the Barrow's Golden-eye is chiefly on the lakes and ponds in the interior of the province. As previously stated they are less common, at this time, on coast lakes. The movement from the coast to the interior extends over a period of six weeks or longer. H. M. Laing (1925) in a voyage north through the inside passage between the islands along the coast in March, 1924, saw Barrow's Golden-eye in flocks of ten

to twelve as far north as Swanson harbour, Alaska, the exact counts being: Trout harbour, March 3, eleven; Prince Rupert, March 5, six and fifteen; Wrangell island, March 7, twelve; Taku Cannery, March 9, ten; Juneau, March 9, twelve; Swanson harbour, March 11, ten. The last four localities are in Alaska. In the spring of 1926 a flock of forty appeared on Vasseaux lake in the Okanagan valley (February 19, 1926), and exactly one month later (March 19, 1926), a flock of similar size was observed on the Cowichan river, Vancouver island. A flock of thirty arrived at the north end of Okanagan lake on March 30, 1926, and this did not represent the end of the migration. On April 21, 1931, a flock of twelve appeared at a place on Okanagan lake which was under daily observation. These birds were asleep on the water when first seen and remained in the vicinity all that day as if resting after a long flight.

Concentrations take place on the lower mountain ponds and lakes as early in the spring as any open water is available and they gradually disperse as the ice melts on other lakes at higher altitudes and these waters become available. The larger lakes are frequented less and it is not usual to find large numbers of birds on them except for a short time in early spring before open water appears on the smaller lakes.

Dates for the first appearance of the species on a series of ponds five hundred feet or so above Okanagan lake are: March 9, 1913; March 22, 1914; March 16, 1916; March 17, 1917. On April 12, 1933, Madeline lake, seventeen miles northwest of Vernon, was becoming free of ice and forty adults and yearlings were on the open water along the shore. A week later, when all the ice had disappeared, the population was reduced to seventeen. Munson's lake, in Dry Valley near Kelowna, was free of ice on April 13, 1933, and eighty adults and yearlings were present. The number was reduced to twelve on May 9, 1933. Other counts on this lake were: April 20, 1934, fifty-eight; May 8, 1937, fifty; April 23, 1938, seventy-five. The total population of Trapp, Shumway and Napier lakes in the Nicola district on April 19, 1933, was seventy-eight individuals.

At this time, as on the wintering grounds, there is a free association between adults and yearlings of both sexes. The courtship period is at its height.

A month or so after their arrival the adults have paired and are scattered throughout the district, some pairs in single possession of small ponds, others in defined territories on mountain lakes. The important factor in their distribution is probably an abundance of food rather than availability of nesting sites.

A large population of yearlings of both sexes continues in occupation of the ponds or lakes which earlier were the scene of lively courtship on the part of the adults. Thus at Rollings lake on May 28, 1919, the popu-

lation consisted of four mated pairs, one yearling male and sixteen yearling females. By the first week in June these flocks begin to diminish in number, the males leaving in advance of the females. Meanwhile some adult males, probably those in which the reproductive process has passed the mating stage, again are present and mingle with the yearlings as they had done earlier in the season, but their stay is short. Through the first three weeks in June a gradual exodus takes place until all save the yearling females have disappeared. The following examples will illustrate the changing populations as the season advances:

On May 25, 1937, a small alkaline lake near Savona contained eight adult males, ten yearling males and forty-two females, most of which were believed to be yearlings, a total of sixty individuals. Two weeks later the population comprised three adult males and twenty-two yearling females.

On the same date (May 25, 1937) a chain of small alkaline lakes near Clinton contained a total of sixteen adult males, fourteen adult females, and eleven yearling females. On June 7, 1937, the population as noted comprised four adult males, six adult females and fifteen yearling females. At this time a number of adult females were incubating eggs and so were not visible. On July 13, 1937, in addition to the females with broods there was a flock of twenty-one females, all of which were thought to be yearlings. By the first week in June segregation of the sexes is almost complete.

In the author's fairly long acquaintance with the species, males rarely have been encountered in the summer subsequent to the breeding season. By the time the first young are on the water usually the last of the breeding males has disappeared and it is unusual to see them after the first week in June. A mated pair, the male actively displaying, was seen on Hunter's lake south of Kamloops on June 11, 1938, this being an exceptional record. A light-coloured male was seen on a small mountain pond on the Monoshee divide in July, 1932, and two others of similar appearance in the Cariboo in August, 1936. These may have been yearling males far advanced in the moult to adult plumage or they may have been adult males in partial eclipse. During July and August of 1936, 1937 and 1938, when this species was being observed nearly every day, a total of eight males was observed; three of these have been referred to, of the remainder three were definitely yearlings and two were adults in full breeding dress. One of the latter was in company with seven yearling females on 150 Mile lake, July 8, 1938; this bird was not present when the lake was next visited on July 22. The other adult male was recorded on Sorenson lake in Chimney creek valley on July 9, 1938. The only

available fall record for an adult male is a specimen collected in the Okanagan valley on October 23, 1918.

At Atlin, Swarth saw six adult males on June 14, 1924, "being first evidence of the impending departure of the drakes and during the next few days southward flying flocks were noted over lake Atlin and elsewhere. No old drakes were seen during the latter part of the summer. One shot on June 30 was beginning to moult into the eclipse plumage" (Swarth, 1926).

The general absence of adult and yearling males in the interior from mid-June to the following spring is of particular interest because it has been recorded by Skinner (1937) that males form part of the summer population in the Yellowstone National Park, Wyoming.

Summarizing the foregoing it can be stated briefly that yearling males (which have associated with the adults on the wintering grounds and accompanied them to the interior in the spring) disappear during the time the adults are absorbed in the reproductive process—the period during which the numbers gradually become less may extend over a month or six weeks. Later the adult males retreat. A large number of yearling females remain all summer in the interior, possibly the entire number does so. In early fall the yearling and adult females and finally the young of the year migrate.

The following dates are of last appearances of young birds on a series of small ponds in the Okanagan: October 11, 1912; October 6, 1915; October 23, 1916; October 24, 1918.

Winter records for Okanagan lake (all young birds) January 20, 1914; January 7, 1916; December 30, 1916; January 15, 1917.

The seasonal movements are outlined in the following table:

January-February	Association of both sexes and all ages on coast waters.
March-April	Migration to interior.
April-May	General concentration on interior waters; adults mate and depart to nesting grounds.
May-June	Gradual segregation of sexes; adult and yearling males gradually disappear; yearling females remain; adult females bring young to water.
July-August	Population restricted to adult females with young and yearling females.
August-September	Adult and yearling females moult and then migrate.
September-October	Young of the year migrate.
November-December	Association of total population on coast waters.

So far as is known no locality frequented by a summer population of adult and yearling males has been discovered, but there is strong presumptive evidence that the location is on salt water. If these males spend the summer on interior waters it seems remarkable that this fact should have escaped discovery. On the other hand the coastal waters, comprising a shore line of 7,000 miles in British Columbia alone, are comparatively unknown ornithologically. Furthermore it is well known that the adult males of other species of inland nesting sea-ducks, for example the Harlequin duck, do make this post-breeding flight to the sea where they associate in large flocks during the flightless period.

However this may be, it is well known that from early fall until spring Barrow's Golden-eye of all ages associate in flocks on the coastal waters both salt and fresh and that only a few individuals winter on inland waters.

It must not be inferred from the foregoing that all the Barrow's Golden-eye which have nested in the interior of British Columbia fly westward to the coast. Very likely there is a migration route down the Columbia valley and east of this also. The species breeds and some individuals winter in Wyoming; a migratory movement also has been observed there. It is not improbable that some birds originating in British Columbia winter in the Rocky Mountain states as well as on the coast regions of Washington and Oregon.

Courtship and Nesting

The courtship period is of long duration, commencing on the coast and reaching its greatest activity in April on the lakes of the interior where large concentrations take place. When displaying the male throws back the head with a quick jerk until the bill points backward, or merely stretches the neck upward to its greatest extent, or makes a succession of quick bows. Usually the head movements are accompanied by a quick backward thrust of the foot that may send spray flying. These actions vary in intensity and have numerous modifications. The male may also thrust his neck forward and thus flattened surge over the water sometimes towards a female but more often in the direction of a second male, or he may dive and emerge close beside another male as if trying to strike from below. The male may display in the presence of females, beside a particular female, or when alone, and the whole performance of bowing or jerking suggests a spasmodic and automatic tic over which the bird has no control. The female may respond by a series of quick bows and sometimes may swing around in a half circle so that she faces away from the male.

A sudden rise from the water and a rapid flight around or above the

lake, through or above the trees, or a circle high in the air are part of the courtship ritual. These actions may be performed by one pair, the female in the lead, or by a female and several males, or by larger groups and sometimes by single birds of either sex. These flights are continued with less frequency during the time that the female is incubating eggs and the males are occupying a territory which she visits once or twice a day.

Thus at Horse lake (May 16 to June 1, 1937) an adult male spent most of each day within a small area along the shore of a wooded peninsula on the L-Y ranch. Here he was joined, usually in the early morning or in the evening, by an adult female and the two fed together on this territory. The female also was seen a number of times flying over the peninsula (where undoubtedly her nest was located) and sometimes was accompanied by the male. One such flight was observed at 5.00 a.m. on May 28 when the female was accompanied by four yearling females and the male followed about one hundred yards behind. One of the females, presumably the adult, uttered a shrill call during the entire flight which lasted five minutes or so—the vowel sound "e" on a high note repeated rapidly gives a fair imitation of the sound. The male called continuously also—a similar note on a lower key repeated less rapidly. These high-pitched notes are quite different from the hoarse croaking note that is heard under ordinary circumstances.

During the courtship period there is a great deal of excited and excessive activity and there is often displayed a considerable amount of apparent hostility on the part of males toward other males. On one occasion (April 26, 1918) the males of two pairs on a small pond were actively hostile, swimming rapidly towards each other and when meeting standing upright and striking with their wings. During an interval between hostilities when the mated birds were together, a third female alighted on the lake and immediately one of the males left his mate and flew to the strange female. He bowed vigorously for a few minutes and then dived and attempted to emerge below the female, whereupon she flew to a distant part of the pond and the male returned to his mate. It was observed on another lake (May 7, 1922) that two yearling males in company kept apart from a group of three mated pairs which were displaying almost continuously and making short flights around the lake. On one of these periodic flights by a mated pair a second male flew in pursuit and followed closely until the pair slanted down to the water when he sheered off. One mated pair on the water drifted gradually towards the two yearling males. When the two couples were fifty yards or so apart the adult male charged over the surface towards the yearlings and drove them to another part of the lake.

A considerable portion of the Okanagan, Nicola, Kamloops, Cariboo

and Chilcotin districts in the southern interior of British Columbia is more or less open, rolling, sparsely timbered country and many of the declivities contain ponds, sloughs or small lakes. The majority of these waters are alkaline to a greater or lesser degree and this governs the amount and variety of vegetation in and around them. The less alkaline are fringed with *Scirpus* or *Carex* or both and usually contain other aquatic plants. Others, more strongly mineralized, show alkaline efflorescence on the hard shores with marginal growth usually limited to *Salicornia europoea* or *Hordeum jubatum*. Most of these waters of whatever alkalinity contain amphipods, phyllopods and other small animals. These alkaline ponds are favoured by Barrow's Golden-eye during the courting period and when the birds have paired off the smaller ponds will be occupied by a single pair only.

There is some competition for certain sloughs, favourably situated as to food and nesting sites, and should anything happen to the pair in possession another pair may move in. Thus when a pair was killed on a small pond near Vernon, April 26, 1918, it was observed, May 14, 1918, that another pair had taken possession of the tèrritory. These waters also serve as nurseries for the young and a family, if not molested, may remain on the same pond for some time after it has reached the flying stage.

The relative value of food and nesting sites in determining breeding locations is a point of interest. Normally a hollow tree or tree cavity is used as a nesting site but the first essential is food and lakes seem to be selected on this basis rather than on the availability of nesting sites.

Rollings lake, a shallow, muddy lake of 300 acres, near Lumby, contains great numbers of amphipods, *Hyalella azteca* and *Gammarus limnaeus*, besides a dense growth of sago pondweed and other suitable foods. The population of this lake has varied only slightly in twenty years in spite of a gradual reduction in the number of normal tree-nesting sites. When this lake was first visited in 1915 a large number of dead, hollow trees were standing close to the lake and some were used as nesting sites. Many of these fell or were cut down from time to time but the Barrow's Golden-eye population decreased very little. The birds evidently adapted themselves to changed conditions and found nesting sites at greater distances from the lake, sometimes a mile or more away. This was confirmed by an observation made on May 23, 1926, when a female followed by ten downy young was seen walking along a dusty road and headed for Rollings lake about three miles away. The nesting population as observed at intervals during the period from 1918 to 1936 was as follows: May 25, 1918, 5 pair; May 28, 1919, 4 pair; June 4, 1925, 4 pair; May 12, 1930, 4 pair; May 18, 1936, 3 pair.

Brants lake, near Summerland, is a long, narrow artificial lake between low, bare hills; normal nesting sites are very scarce, indeed no tree-nesting sites have been found. The lake contains numerous amphipods. The population on May 12, 1918, comprised twelve mated pairs and six yearlings and on June 20, 1920, ten females with broods averaging six young as well as a small number of yearling females.

Through these regions also, generally at higher altitudes, are many other nesting grounds comprising true mountain lakes with deep, fresh water and wooded shores. If these contain suitable food, as most of them do, they may support a large nesting population. For example, Paul lake, three and one-half miles long, was occupied by eleven pairs in 1936 and nine pairs in 1937.

Precipitation is an important factor in relation to reproduction. In average years all ponds contain water and evidently food but during periods of decreased precipitation many ponds are greatly reduced in size or dry up entirely and as a consequence local populations decrease in numbers.

A series of small ponds near Vernon maintained about the same population of Barrow's Golden-eyes during the period 1911 to 1920. These were years of average precipitation and all of the ponds contained water. Some of the ponds dried out during a period of decreased precipitation from 1928 onward and the duck populations decreased. Similar observations in later years were made in the Cariboo region and it would seem that the amount of suitable water available has a very direct bearing on the size of the Barrow's Golden-eye population.

In British Columbia the Barrow's Golden-eye usually lays its eggs in a tree cavity which may be a hole in a live tree, a low tree stump hollowed out by fire or decay, or a tall dead stub. While laying is in progress, and afterwards, the female plucks down from her abdomen and places it in the nesting cavity. The amount varies in quantity in different nests; in some it is sufficient not only to insulate the circumference of the nest but to cover the eggs as well. Most of the sites that have been described were in or close to water but it is probable that the majority are located at a distance from water. Nests have been found by watching a female fly from her feeding ground to the nesting tree, by the detection of down adhering to the edge of the nesting cavity, or by accidental discovery.

A. Brooks (1903) refers to a nest in a hole fifty feet from the ground in a Douglas fir that was situated about 400 yards from the nearest water. Munro (1918) describes three nests discovered in the Okanagan valley and (1935) records a nesting site in the burrow of a Yellow-footed Marmot, *Marmota flaviventrus avara.*

The author discovered another nest at Rollings lake on May 28, 1919, an illustration of which appears without detailed description in Bent (*loc. cit.*, plate 6). This was situated in a hole near the top of a twenty-five foot fir stub standing in water close to the lake shore. The cavity contained six eggs and a large quantity of down. So far as known the foregoing are the only published descriptions of nests found in British Columbia. Skinner (1937) reports that all the nests he found were in hollow trees, "either standing on the shore, or within a hundred feet of lakes, small natural ponds, beaver ponds or streams". The few additional American records of nesting all refer to nesting sites in trees.

In Iceland the manner of Barrow's Golden-eye nesting is quite different. J. G. Millais (1913), as quoted by Bent (*loc. cit.*, p. 17), states that the nest is usually placed "in a hole in the bank of a stream flowing into a lake, in a hole in the lava rocks close to the water, or on some low island under bushes of dwarf willow, or dwarf birch, amongst coarse grass or low shrub".

No observations of the method by which downy Barrow's Golden-eyes leave their nests (some of which are situated fifty or more feet from the ground) have been recorded. Very probably the young tumble out of the nest in the same manner as do the downy American Golden-eye (Bent, *loc. cit.*).

Reports of young Barrow's Golden-eye being carried to the water one at a time in the bill of the mother, or on the mother's back, belong to the annals of folklore rather than to natural history.

Behaviour of Yearlings

There is no evidence that yearling Golden-eyes breed although during the spring there is some manifestation of sexual excitement amongst them and they go through various performances which in the adults form part of the reproductive process. A yearling male has been observed to fly in pursuit of a yearling female which had taken wing from the surface of a pond, circle the pond, then splash into the water and after a quick dive take flight again. Similar actions may be performed by two young females. Moreover, yearling females have been seen entering tree cavities that were suitable nesting sites. Thus at Nicola lake on June 15, 1917, five yearling females passed in rapid flight through and over the cottonwoods along the lake shores, after which they splashed into the water and paddled ashore where all stood close together on a prostrate log. Later several flew into nesting holes which inspection showed to be unoccupied. No adults were in the vicinity. At Rollings lake, May 28, 1919, a yearling male, with white crescent on the head, acted as if mated

to a yearling female. The two birds remained close together and did not associate with the other golden-eyes on the lake.

Sometimes yearlings may invade a territory occupied by a breeding pair where they make display flights and perform the various courtship actions.

At Horse lake (May 26 to June 1, 1937), a territory, occupied by a breeding male whose mate was incubating, was visited by a number of yearling females, as stated earlier. Precisely the numbers were five on May 28, ten on May 30 and seven, accompanied by a yearling male, on June 1. Their visits took place in the early morning and after feeding they rested, usually inside a pole corral which was built half in the water and half on land immediately in front of a log stable. Here they relaxed, some drifting about on the water, others crouched on the poles above it.

It was observed at Paul lake and elsewhere that a single yearling female may become attached to a breeding pair and continue the association after the male has left, remain in the vicinity during the time that the female is incubating and resume the association when the female has led her brood to the water.

The following incident, observed on a small lake near Kamloops on June 11, 1938, suggests also that a yearling female may sometimes take forcible possession of a brood. A yearling female pursued and drove on to the shore an adult female which was leading a brood of seven downy young. When reaching the shore the yearling grasped the tail of the adult in her bill and held on while the adult with difficulty struggled over the stony ground, dragging the second duck. Six of the young followed close behind, tumbling over one another and over the stones that impeded their progress; the seventh young bird remained on the water. The yearling finally relaxed her hold, flew to the single young bird on the water and the two swam off together. The adult female led the six young to the water and swam away in a different direction.

Until about the end of July yearling females are present on many of the lakes occupied by females and their broods; for example, on a small lake south of Clinton, twenty-three were gathered in one flock on July 13, 1937. By early August many of them have left these lakes and joined other species of diving ducks on certain waters favoured during the flightless period. For example, at 103 Mile lake on August 14, 1937, approximately sixty, some of which may have been post-breeding females, were associated in a large raft with Buffle-head, Lesser Scaup and Ruddy Duck, most of them being flightless. All but one of the Barrow's Golden-eye were females, the exception being a yearling male. Another similar raft on 105 Mile lake (August 6, 1937) contained about eighty females; most

of these also were flightless. By August 25, 1937, all the ducks present on these two lakes were in flying condition.

A total of 150 (estimated) yearling females was present on Green lake, July 27, 1937. Some were associated with a large flock of non-breeding White-winged Scoters, and two separate flocks of seventeen and twenty-five were counted. The mineral content of this lake is high and the waters are very clear; it contains none of the plant foods eaten by ducks nor do any cover plants grow on its shores, consequently it is not used by nesting ducks. There are numerous amphipods in the lake and it seems likely that this food attracts the non-breeding water-fowl.

The appearance of yearling females in the Cariboo region becomes progressively lighter in colour as the summer advances. Usually the head fades to buffy brown, even showing areas of white where the pigment has entirely disappeared (Plate I). Flanks, chest, tail and back may become so light that the bird has the appearance of an albino. Adult females usually show less fading; possibly the time spent in darkness while incubating eggs may retard plumage disintegration. Another pertinent factor may be the generally different summer habitats of adult and yearling females; the former more often frequenting shaded lake margins and the latter the more open waters.

General Observations of Females and Young

In life the well-grown young seem darker than the adult female which usually accompanies them, and still darker than the generally more faded yearling females. Under normal condition of observation the brown colour of the head appears to be blacker in the young than in the adult female, in which, at this season, it has usually faded from the deep, rich brown of spring to a more tawny, golden shade. The young birds have a sleek, trim appearance while that of the adult is unkempt. Other age distinctions noticeable in life are the absence of the white collar in the young and the difference in colour of the iris, which is clear yellow in the adult female and dark amber in full-grown young.

Females sometimes leave their broods (in order to moult) before the young are able to fly and when this occurs the brood may hold its entity, or it may scatter, or it may join with other broods. Thus at 150 Mile lake on August 2, 1937, a band of seventeen young, well-grown but unable to fly, was unaccompanied. For a time this particular band was led by a female Lesser Scaup. Various other instances of unaccompanied young might be cited.

On small lakes inhabited by a large, mixed population of diving ducks the female plus brood association is less apparent than it is on large, thinly populated lakes. In the former, ducks of several species, of both sexes in

some species, and of all ages congregate in rafts and when this happens broods of Barrow's Golden-eye lose their identity at a comparatively early stage of development. These large associations of several species of ducks, which usually contain American Coot, *Fulica americana americana* and Holboell's Grebe, *Colymbus grisegena holboelli* also, have a decided survival value for all concerned; all of the individuals comprising it become exceedingly wary and the actions of the young Barrow's Golden-eye, diving and hiding when first alarmed, are in marked contrast with the action of those on other waters where these mixed associations do not occur.

This tolerance of other species, including coots, observed on crowded lakes, is not always the case elsewhere. On a small pond (July 9, 1915) a coot that tried to feed with a brood of half-grown Barrow's Golden-eye was repeatedly attacked by the adult female, who rushed over the water and struck the coot with her bill. (It has been reported verbally that coots kill young Barrow's Golden-eye, but no instance of this has been observed by the author.)

The adult females leave their broods early in August and proceed to moult; the flightless period is estimated to be two to three weeks. A specimen collected on August 6, 1937, still carried some of the secondary wing feathers; the new primaries were sheathed; the tail feathers faded to pale drab; the bill brownish olive with a suggestion of dusky yellow on the sides of the terminal third and the inter-ramil region; the iris clear yellow; the ovaries small.

Females which have raised broods on some of the larger mountain lakes where there is competition for food may fly some distance just prior to the moult and join the yearling females, the Lesser Scaups and other ducks, which probably have commenced moulting earlier. This is an assumption only; moulting adult females possibly may remain on these nesting grounds and hide so successfully as to escape observation. It seems clear that on certain other lakes (which, in addition to being nurseries for young Barrow's Golden-eye are used also as retreats by other diving ducks during the flightless period) the adult females remain and, with their young, form part of these mixed populations.

The adult females leave the interior before the young of the year, very likely shortly after the moult and in company with the yearling females. This statement is based upon the author's extended observations which show that the interior autumn population is almost entirely restricted to birds of the year. These may appear in small companies up to six or seven, perhaps in some cases representing definite broods originating on a small lake where there was no tendency to separate, or else in flocks of relatively large numbers. Such flocks are sometimes seen in the late

summer prior to any general migration of adult females and yearlings. Thus at Goose lake near Vernon on August 10, 1919, a flock of fifty had assembled.

POPULATION STUDIES

The general behaviour of breeding birds in the spring and of summer populations is illustrated in the following studies, one made at Paul lake and adjacent lakes, the other at Horse lake in the Cariboo District. The first describes the behaviour of mated birds and females with downy young; the second is chiefly concerned with the behaviour of females and older broods.

Paul lake

Paul lake is situated in a narrow, mountain valley between the North and South Thompson rivers, at an altitude of 2,550 feet, about twelve miles northeast of Kamloops. It is approximately three miles long and one-quarter to one-half mile in width. The surrounding steep mountain slopes are covered by coniferous forest with trembling aspen replacement on burnt-over areas. Shoreline tree-growth consists of Douglas fir, yellow pine, black cottonwood, trembling aspen, mountain birch and Sitka alder. Several low-lying tracts on the north side subject to inundation are partly covered by low brush, chiefly willow and dogwoods, and this vegetation is general east of the lake in the valley bottom through which flows a tributary stream draining Pinantan lake two miles distant. (Paul lake drains into the North Thompson river through a rapid stream which leaves the lake at its western extremity.)

This lake provides the food and shelter necessary for the production of a large population of Barrow's Golden-eye. Along much of the shore line for a short distance out the waters are shallow enough so that diving ducks may secure food without difficulty; elsewhere the lake is deep and feeding grounds are therefore limited to shoreward areas. The bottom vegetation is chiefly *Chara* and rich in such food organisms as amphipods, gastropods, pelecypods and the larvae of numerous species of insects.

Nesting requirements are available close to shore where many dead trees of large size, sheltered by surrounding live growth, remain upright, while on the rocky forested mountain side other less conspicuous sites, such as rock crevices, perhaps are used. One nest in the hollow, dead top of a live Douglas fir was definitely located. Resting places are provided by stretches of shore-growing brush overhanging the water, by prostrate tree trunks anchored by their branches to shore and lake bottom, and in the flooded brush-covered sections.

In order to enumerate the Barrow's Golden-eye population and to obtain qualitative data concerning their life-history, Paul lake was visited

during 1936 for the period May 11 to May 15, on June 16 and 17, and on July 20 and 21. On each occasion a survey by canoe was completed. During the intervals between visits to the lake, Mr. Lyle Crowe, who spent the entire summer at Paul lake, undertook to keep a record of the number of adult males present, and later, so far as apossible, of the broods. His observations are included in the following account.

Adult and Yearling Population

Population counts during the period May 11 to May 15 were made on three days at different hours. At this time mated pairs were in possession of definite territories, comprising shallow inshore areas, and the procedure in counting was to paddle slowly along shore until birds were sighted and then to make a wide outward semi-circle in order not to put them to flight. By so doing the chance of counting the same birds twice was lessened.

It was established that the breeding population consisted of thirteen pairs; of these one pair, and the mate of a female believed to be incubating eggs, were collected for the purpose of stomach analyses. The population then consisted of eleven adult males, twelve breeding females and in addition, six non-breeding females, most of which were considered to be yearlings. No yearling males were on the lake.

There was, of course, no difficulty in identifying the males as *islandica*. In the case of most of the females it was possible, at one time or another, to approach close enough so that through 6X binoculars the contour and colour of the bill could clearly be seen. The latter character at this time of year served with a fair degree of certainty to distinguish old females from yearlings, in which the yellow coloration is less pronounced. A dissimilarity in the colour of the iris, noticeable in freshly taken specimens, was not apparent in life. Later in the season the difference in bill coloration due to age could not readily be detected in life but was apparent in freshly killed specimens. Thus, in the case of two non-breeding females, an adult and a yearling, collected on June 17, 1936, the colours of soft parts were recorded as follows:

No. 1 ♀ adult, iris wax yellow; upper mandible chiefly faded yellow to cream with dark brown base and black nail; rami honey yellow and inter-ramal region olive brown; tarsi honey yellow. This bird had well-developed ovaries but apparently had not nested as no down had been plucked from the belly.

No. 2 ♀ yearling, iris oil yellow, decidedly more greenish than No. 1; upper mandible fuscous, area behind nail clouded with saccardos umber, nail black; rami olive brown; inter-ramil region honey yellow; tarsi yellow ochre. (Colour-terms are those of Ridgeway, Color Standards and Color Nomenclature, 1912.)

According to the observations of Mr. Crowe, the adult males began to leave the lake shortly after the author's first visit was concluded, and the last was seen on June 8. His counts are as follows: May 16, eleven; May 18, seven; May 20, five; May 22, seven; May 25, five; May 26, four; May 27, four; June 1, six; June 2, six; June 5, six; June 6, two; June 7, one; June 8, one.

Mr. Crowe also reported that in the period June 1 to June 5 six adult males, sometimes accompanied by twelve or more females, which were identified as yearlings, associated in one flock. They appeared to be restless, flying from one place to another near the west end of the lake. At this time also an evening flight over the lake was observed several times. The number of birds was not counted.

Distribution

From May 11 to May 16, mated pairs were distributed as follows: one pair in a swampy bay at the outlet of Paul creek; two pairs about one mile apart on the south shore; eight pairs along the north shore. The latter district is the most desirable in respect to nesting sites, food and shelter; it includes sloping shores overhung with brush and an area of willow and dogwood swamp in which are several beds of *Scirpus* and *Typha*. The territories of four pairs centred about this swamp, which is a mile long and two or three hundred yards wide.

With two exceptions the mated pairs were always seen together; evidently at this time most of the females were laying and the periods spent on the nest were of short duration. The exceptions noted refer to males in single occupation of territories which they seemed loath to leave even when approached within a few yards; possibly in these cases the females had commenced incubation but the sexual process of the males had not reached a comparable stage.

Each pair remained fairly constantly within an extent of shore line which varied in length at different parts of the lake—the territories on the more populated north shore being smaller and less well defined than those on the south shore. Here the golden-eyes might sometimes be seen feeding but more often resting on the water or on one of the numerous prostrate trees lying at right angles to the shore or projecting above the surface of the lake. These latter, standing at various angles, several with ends broken five feet or more above the water, were favourite perches.

The posture of a resting bird was one of complete relaxation, the belly pressed against the log, the tarsus flexed and the bill hidden in the billowed chest. A female resting in this manner upon a half-submerged log was visited by a male, presumably her mate, which was seen first flying swiftly, low down, over the still lake. When quite near, with steadied

wings and out-thrust feet braking the swift flight, he splashed into the water and a moment later climbed on to the log and crouched down close to the female.

These periods of rest were subject to various alarms and interruptions caused by passing fishermen, but while the ducks would submit to a close approach without moving from their resting place they showed increasing signs of awareness as an observer drew nearer. Usually a duck thus disturbed would rise on its toes and after some hesitation step into, or fly down to, the water; rarely did it take flight.

While for the most part the males remained close to their mates, occasionally one, or sometimes two or more in company, made excursions into an adjoining territory and joined the pair that was in occupation. When this took place little demonstration of sexual excitement was made by any of the birds which had come together, as would have been the case at an earlier stage of the reproductive period. Not infrequently a male left his mate and performed a short flight. This was the only part of the nuptial display observed at Paul lake. Very often one of the yearling females attached herself to a mated pair, several such trios being encountered at different times. Such associations were not constant, as the yearlings would sometimes return for a short time to the small flock of non-breeding females which for the most part kept together. Subsequent observations elsewhere of normal sized broods accompanied by two females suggested that a companionship between an adult and an immature female persisted after the male had left and continued through the entire summer. No doubt while incubation was in progress the breeding female, during the times spent on the water, would join the yearling and thus the connection would be maintained until such time as the young were brought to the water; after which the two females would again be in close association.

Summer Population

By June 17, two broods, of eleven and twelve respectively, had been brought to the water; the only other Barrow's Golden-eyes seen on that date were three yearling and one adult non-breeding female which were together when observed. Two of these were collected as has been noted. The females which still were incubating eggs did not appear on the lake at the times it was under observation.

During the interval between June 17 and July 21, when the lake was next visited by the author, Mr. Crowe kept a record of several broods, which were seen at different times on definite territories, in order to establish the date of their first appearance and the rate of survival. Circumstances did not permit detailed inspections so that all the broods were

not enumerated, and no doubt Mr. Crowe sometimes did not see all the members of a brood, nevertheless his observations as tabulated below are of value.

No. 1—June 21, five or more; June 30, six; July 6, ten; July 8, nine.
No. 2—June 27, nine; June 28, nine; June 29, nine; July 13, nine.
No. 3—June 28, three; June 30, three; July 1, ten.
No. 4—June 28, eight; June 30, eight; July 1, eight.

The total population on July 21 was as follows:

3 adult ♀ with broods	3, 8, 12	$\frac{1}{4}$	grown
2 " ♀ " "	2, 8	$\frac{1}{3}$	"
4 " ♀ " "	2, 3, 6, 8	$\frac{3}{4}$	"
Young not accompanied	2		
Non-breeding ♀	7		

Total population 70, of which 52 were young.

Of the eleven mated pairs observed in May, nine had succeeded in bringing broods to the water. The average number in a brood on July 21, that is, approximately a month after hatching, was six, which represents a survival of 66.6 per cent on the basis of an original average of nine young to a brood.

It is difficult to account for the loss. On the assumption that it is caused by natural enemies it would be necessary to consider horned owls, which are known to nest near the lake, and loons, of which one pair nested but did not raise young. There was no evidence of other predators being present. Neither coots nor grebe nested on the lake. The partially decomposed carcass of a half-grown Barrow's Golden-eye was found floating on the lake and an examination of this specimen, necessarily superficial because of the bird's condition, showed no sign of bodily injury. This was the only evidence which suggested predation.

Behaviour of Young

In most cases a brood when first detected was close to shore, often under the shelter of overhanging brush. Sometimes the young birds swam in a massed flock, again in single file behind the female. One brood of nine was grouped about an adult female resting on a half submerged log and in the water close by lingered a second female, probably a yearling, which had attached herself to the family. A brood of eight, about one-third grown, swam out from shore keeping close together and commenced diving for food close to the canoe in which the observer was seated. After a short submersion the small birds popped up buoyantly to the surface, one at a time, and in a second or so dived again, exactly as adults do when feeding. As the canoe drifted closer, the birds re-

assembled in a flock, their heads, on which white cheek patches were still prominent, all pointed in the same direction as the little group followed close behind the female. For a few minutes they swam thus, then strung out one behind the other with the female leading.

Elsewhere the downy young have been seen feeding from the surface, gliding rapidly along and making quick darts from side to side during which they picked up small objects, perhaps insects, from the water.

On May 19, 1937, the population consisted of nine pairs and five yearling females. The territories occupied by the breeding birds were practically the same as those occupied in 1936. In three instances mated birds were feeding or resting on their respective territories; they were very tame and kept close together; the other territories were in possession of males only, the females probably being on their nests. One male was mated to a female which had an entirely dark bill.

Horse Lake

Horse lake (altitude, 3,600) is eight miles long with a maximum width of one mile and lies almost due east and west. It is a deep lake and contains the food necessary for the support of a large fish population (including Kamloops trout, lake charr, squawfish, suckers and lake shiner) as well as various waterfowl of which Barrow's Golden-eye is the most conspicuous during the breeding season.

The land on the north side rises steeply from a narrow flat which terminates in a stony beach. Part of the slope is covered with Douglas fir, lodge-pole pine and poplar forest; the remainder is open grass-land broken at almost regular intervals by brushy draws. The shoreline tree-growth is chiefly poplar, willow, dogwood and alder (the latter overhanging and screening the stony beach in many places) and farther back from the water taller, isolated balm-of-gilead and scattered Engelmann's spruce. There is no marsh growth on this side of the lake. Along the south shore are low, timbered mountains; between them, open draws slope to the lake and end in wide flats or benches; adjacent to these flats are stretches of boggy ground covered with willows and various species of sedge *Carex*. The prevailing type of overhanging alder cover is present along the narrow base of the timbered, mountain portions. It was noted time after time how dependent upon this growth were young golden-eyes when seeking cover, also that the shallows directly beneath them were the most important feeding grounds. From a point near the west end of the lake for a distance of approximately three miles eastward, the water shallows inshore and a continuous belt of *Scirpus*, of varying width and density, is present.

At both ends of the lake, the inlet and outlet respectively of Bridge

creek, are shallow areas with *Typha*, *Scirpus* and *Carex* marshes. The bottom is sandy and supports a considerable growth of various *Potamogeton*, *Ceratophyllum*, *Myriophyllum*, *Utricularia*, *Sagittaria* and other aquatic plants interspersed with areas where yellow pond-lily, *Nymphaea*, is dominant.

In these shallows is an abundant supply of small animals including snails (*Planorbis*, *Lymnaea* and *Physa*), insect larvae, leeches and amphipods, but the latter are more plentiful in the main body of the lake where the dominant bottom growth is *Chara*.

A wide, shallow bay with a marl bottom, on the south side of the lake two miles from the eastern end, is less well supplied with aquatic plants and their attendant animals except along the *Typha* and *Scirpus* fringed shores where the marl contains a larger admixture of humus. Extending from the mouth of this bay westward is a narrow reef where the water shallows to eight feet or less and over a portion of this reef is an "island" of *Scirpus* roughly fifty by three hundred yards. Amongst these rushes, which are so widely spaced as to offer no obstacle to the progress of a canoe, are various long-stemmed plants, including *Potamogeton natans* and *Potamogeton foliosus*, rising through the clear depths. Both these plants and the sturdier rushes form emerging ladders for the larvae of aquatic insects and clinging places for snails. This reef proved to be an important feeding ground for Barrow's Golden-eye, as did the other shallow areas mentioned.

Studies of the summer population of Barrow's Golden-eye at Horse lake were carried on during July and August in 1936 and 1937.

Observations in 1936

The association of two females with one brood was noted several times but it was not always possible from observation to decide if one of these was a yearling, although, from the different actions of the two individuals when alarmed, it seemed probable that the associations were similar to those observed at Paul lake.

When females with broods were approached it was unusual for the parent to fly; more often the female, slightly in advance of the young which swam sometimes in single file, sometimes in a compact flock, led them to open water or, if near shore, to the shelter of the overhanging alders. Here they would dive and separate to reappear at various points along the shore. This was the behaviour most commonly observed but, as is the case with other duck species, certain individuals showed less concern about their young than did the majority. Thus on a small pond near Horse lake, occupied by a female with twelve small young and a second female with ten young, two different reactions to alarm took place.

The first female led her brood, in the normal manner, to a distant part of the lake; the second when first detected was ten yards or so from one group comprising five of her brood and continued diving there, amongst a growth of lily pads, while the five young swam towards and finally joined the rest of the brood which were swimming alongside a wooded bank about a hundred yards distant.

It was observed that many broods of young break up at a comparatively early stage. It was common to see one, or more often two, young birds frequenting certain stretches of shore line and to find them in the same place day after day. After the brood has once broken up the female apparently does not attempt to bring the young together again. The brood of nine, from which one was collected on July 24, became scattered shortly afterwards and the female disappeared, probably to moult. One individual of this brood remained within a quarter mile stretch of shore line where it was seen whenever this particular area was visited and was last observed on August 23, nearly a month later.

When a brood has strayed the female may attach herself to another brood, but in such cases, and they were noted frequently, there is some doubt whether the second female is an adult or a yearling. At this season the character of bill coloration is not available as a means of age determination, nevertheless yearling females usually can be distinguished from adult females by the relatively lighter colour of the former. When two females attend a brood usually only one shows concern for the young in the presence of enemies. Thus in the example of the two females with a brood of nine recorded above, one female remained with the brood and the other flew away and was not seen to return, although it was again with the brood on the following day when it acted in a similar manner.

This straying of young and joint caring for a brood by two or more females may be well illustrated by setting forth the population on a two-mile stretch of Bridge creek which on July 27, 1936, was as follows: female, six young; female, one young; female, one young; brood of four without parent; brood of three accompanied by three females.

Possibly bald eagles may be implicated in the general scattering of golden-eye broods. Two pairs of bald eagles had nested earlier on the shore of Horse lake and, while no instance of their attacking golden-eyes was personally observed, one such instance was reported by a local resident; also a headless body of a half-grown golden-eye was found under a fir tree near one of the eagle's nests.

On August 18, 1936, all the young golden-eyes recorded had reached the flying stage and there were no definite broods. As was the case earlier in the summer these birds frequented the edge of marsh areas or shallow water close to the wooded shore sometimes under the overhanging

branches of willows and alders. The numbers of birds for a distance of two miles of lake shore on August 18, 1936, was:—1, 1, 3, 1, 1, 2, 2, 2, 2, 1, —a total of 16. All these were tame and usually it was possible to paddle within a few yards before they became alarmed and flew. Their tameness was particularly apparent when they were feeding close inshore under the overhanging branches or resting on some log or fallen tree extending out from the lake's edge.

Observations in 1937

In 1937 studies of the summer populations were resumed on July 14 and continued at intervals until August 26.

On July 22 the population as counted during a circuit of the lake by canoe comprised four non-breeding females, probably yearlings, fourteen females accompanied by young, none of which had reached the flying stage, and four half-grown young not accompanied by an adult female. The numbers in the broods were as follows: 1, 1, 4, 5, 6, 6, 7, 8, 8, 9, 9, 9, 16, 19. No doubt both the two large bands included a number of young which had strayed from their rightful mothers. The average number in a brood, approximately a month after hatching, was eight.

Some of these broods when first seen were feeding or travelling along shore, others were resting on logs either on or close to the shore. In two instances the female left her brood when disturbed; in all others the females remained with the young.

It was observed that with some exceptions the young remained in their respective broods (a condition which was less evident during the same period in 1936), also that they made somewhat extended journeys along the shore, returning later to the areas usually occupied. Thus a band of nineteen led by one female was seen first on July 15, again on July 21 at the same place, but on the following day was found three miles to the east. These particular birds were all of similar size and when floating high on the water, as normally they did, looked as large as the adult female which accompanied them. When alarmed they sank lower in the water so that not much more than the head and top of the back were visible; in this position they looked much smaller and the greater size of the female was readily apparent. When swimming in the normal manner they kept close together, sometimes in a line, sometimes "bunched". In the second position the young ducks often were so close that their flanks almost touched; in the first position the head of one bird was close to the tail of the bird in front.

At one time these particular golden-eyes were under close observation for half an hour while they dived for food and it was seen that they submerged almost simultaneously while the female always remained on the

surface as if on the watch for enemies. A band of sixteen, which was feeding within or beside an open growth of bulrush close to shore, behaved in the same manner. This second group included birds of several ages, some with completely brown heads, others with patches of white down on the cheeks. They were remarkably fearless and when following them slowly in a canoe it was possible to approach within twenty feet of them before they increased their leisurely swimming speed. Only when the distance between canoe and ducks diminished to ten feet or so did they show alarm and scamper over the water.

A second complete census was made on August 19 when the population, so far as could be determined, consisted entirely of young of the year. Apparently both the adult females which in late July were accompanying broods and the small population of yearling females had left the lake, presumably to moult. Either this was the case or else they were so shy in their flightless condition and hid themselves so well as to escape observation. Many of the young were solitary and the largest number seen together was eight. They were scattered at intervals along the twenty-three miles of shore line, feeding in the shallows close to overhanging alders, in or at the edge of the numerous bulrush beds, or else a short distance out from shore. None was seen on the open lake. The majority had reached the flying stage but some were stronger on the wing than others; this was apparent even among members of the same flock or brood.

The following is a list of the birds as encountered: 1, 3, 1, 2, 1, 1, 1, 4, 5, 2, 2, 1, 2, 4, 5, 1, 2, 1, 3, 2, 8, 2, 3, 5, 2, 1, 1, 3, 2, 1, 1, 2, 2, 3, total 80 Thus of the 116 flightless young representing fourteen broods observed on July 22, eighty had survived, and most of them had reached the flying stage, by August 19.

On the basis of an original average of 9 young to a brood (as computed for Paul lake and elsewhere) the survival at approximately one month and two months after hatching was 92 per cent and 63.5 per cent respectively.

Summer Population Counts

The following presents a record of summer populations on certain waters where enumerations could be made with a fair degree of accuracy.

SUMMER POPULATIONS OF BARROW'S GOLDEN-EYE

Locality	Date	Adult ♀	Young	Yearling ♀	Adult and Yearling ♂
Brant's lake	June 20, 1920	10	60	8	0
Clinton lakes	July 25, 1933	5	38	3	0
	July 22, 1936	13	65	5	0
	Aug. 24, 1936	0	79	4	0
	July 13, 1937	8	38	30	0
	June 30, 1938	13	81	24	0
	Aug. 18, 1938	0	113	0	0
Horse lake	July 22, 1937	14	116	4	0
Disputed lake	July 29, 1936	2	22	0	0
	July 25, 1937	2	14	0	0
Longbow lake	July 29, 1936	0	0	1	0
	July 25, 1937	2	12	0	0
Irish lake	July 26, 1937	2	16	0	0
Green lake	July 27, 1937	0	0	150 (est.)	0
103 Mile lake	Aug. 8, 1936	15	27	17	1 yearling
	Aug. 4, 1937	20	26	40	0
	July 19, 1938	4	32	6	0
105 Mile lake	Aug. 6, 1936	1	4	9	1 yearling
	Aug. 6, 1937	1	21	0	0
	July 3, 1938	2	13	1	1 yearling
	Aug. 6, 1938	1	20	30	
Lily Pad lake	Aug. 7, 1937	5	16	25	0
149 Mile lake	July 31, 1936	4	22	9	0
	Aug. 2, 1937	1	20	0	0
	July 12, 1938	4	39	0	0
150 Mile lake	July 31, 1936	2	9	7	2 yearling
	Aug. 2, 1937		17		
	July 8, 1938	1	8	7	1 adult
Paul lake	July 21, 1936	9	54	7	0
Anthony lake	Aug. 5, 1936	1	17	0	0
Mirage lake	Aug. 1, 1938	0	0	15	0
Tad lake	Aug. 1, 1938	1	18	0	0
Cummings lake	Aug. 10, 1938	4	39	0	0
Westwick lake	July 9, 1938	4	34	13	0
Sorenson lake	July 9, 1938	5	31	13	1 adult

Survival of Young

The following table was prepared to show the rate of the survival of young as the summer season progressed. Except in a few instances circumstances did not permit the counting of broods in any one locality more than once so that these enumerations have only a limited value.

1936	1937	1938
July 21—2, 2, 3, 3, 6, 8, 8, 12.	July 13—2, 3, 5, 5, 6, 7, 7.	July 9—4, 5, 6, 7, 7, 8, 9, 9, 10.
" 22—2, 3, 3, 4, 5, 5, 5, 5, 5, 5, 6, 6, 7, 7, 8.	" 20—5.	" 12—6, 6, 8.
" 23—9.	" 22 - 1, 3, 4, 5, 5, 6, 6, 7, 8, 8, 9, 9, 9, 16, 19.	" 13—6, 6, 6, 6, 8.
" 27—3, 4, 6.	" 25—5, 6, 7, 8.	" 15—8, 13.
" 29—10, 12.	" 26—7, 9.	" 18—4, 5, 6, 8, 9, 9.
" 31—2, 6, 7, 7, 7.	" 31—5.	" 20—4, 14.
Aug. 4—4.	Aug. 2—5, 5.	" 21—8.
" 5—6, 11.	" 3—3, 4, 6, 7, 8, 8, 9.	" 22—3.
" 8—6, 7.	" 4—5, 6, 6, 9.	" 23—7.
	" 6—8.	" 27—6.
	" 7—8, 8.	Aug. 1—9, 9.
		" 10—6, 6, 9, 9, 9.

Winter Populations

Information is lacking as to the dates upon which the adult females, females, yearling females and young of the year appear on the coast in the autumn. Birds of both sexes and all ages were common on Henderson lake, Vancouver island, November 10, 1922, but undoubtedly had arrived some time before this date. It seems probable that part, at least, of the southern interior population winters on the British Columbia coast, rather than on more southern coast localities, and the arrival of these birds would likely be at different periods following closely on the departure from the interior of the different age groups, which commences in late August and continues through September, October and November. By late October most of the males from the previous year would be in adult plumage and these, together with the older males, presumably are on the winter grounds when the interior summer population arrives.

Barrow's Golden-eye seems to prefer fresh or brackish water to the more highly saline water. Thus we find the species common on coast lakes and rivers and in waters adjacent to the Fraser river. It winters commonly in Burrard inlet and Howe sound where the water is comparatively fresh, but according to the author's experience, is scarce on the east coast of Vancouver island where the waters are more saline. At Departure bay, during parts of ten winters spent there, a total of four individuals only was observed. Apparently the toleration of the species for water with a highly saline content is limited and the chief wintering grounds are on the rivers and lakes.

Probably also the food supply has a definite bearing on the winter distribution. As with the American Merganser, salmon eggs are one of the chief winter foods and wherever salmon have spawned the Barrow's Golden-eye is likely to occur. Usually it is associated wtih American Golden-eye but only a small percentage of the latter frequent fresh water.

(This species is a true sea-duck during the winter and frequents even the most saline waters.)

The Cowichan river on Vancouver island usually attracts a mixed population of golden-eyes, as do the Chemainus, the Courtenay, the Nanaimo and other streams.

On Clements creek, tributary to Henderson lake (November, December, 1922), Barrow's Golden-eye represented about ninety-five per cent of the golden-eye population, which varied from ten to one hundred and sixty estimated (Munro, 1922). This condition has not been observed elsewhere on the salmon streams along the coast.

Restrictive Factors

Various factors operate to hold populations at about the same level from year to year—excluding the periods when a general reduction is brought about by drought conditions in the dry belt. Hunting is not so important a factor as it is with some other species of ducks for reasons which are given later. As the Barrow's Golden-eye usually nests in hollow trees the eggs are not commonly taken by crows and other predators as is the case with many other species of ducks. Horned owls and bald eagles prey upon both adults and large young and no doubt other forms of predation occur. An account of probable predation by horned owls at Rollings lake in the Okanagan valley has been recorded by Munro (1929).

Another instance of predation, probably by a horned owl, was observed on a small, rocky inlet in 105 Mile lake, Cariboo, August 15, 1938. The freshly severed wing of a young male Barrow's Golden-eye was found on the shore; beside it was fresh blood, several horned owl feathers and a large owl pellet composed of duck feathers. Elsewhere on the shore were scattered the remains of three young Holboell's Grebe, indicating this to be a favoured feeding place for horned owls.

Broods of young golden-eyes during the first few weeks of life are reduced by various misadventures which in some districts (according to report) include destruction by crows. Very often small downy young become lost and lacking the care of the parent become casualties. Unattached downy young frequently are encountered: for example, on June 8, 1911, two downy young a few days old were seen on Okanagan lake far from any known nesting site. These were struggling to maintain their equilibrium against the force of white-capped waves that rolled up on a stony beach; a similar incident was witnessed at the same place several years later. It seems probable that many downy young are killed by exposure to rough water on some of the larger lakes.

FOOD STUDIES OF BARROW'S GOLDEN-EYES

Feeding Habits

The feeding habits of the summer populations on the small lakes of the interior are recorded in the section, "Population Studies". The behaviour, common to both species of golden-eyes, when feeding on the larger lakes of the interior and on coast streams has been described, Munro (1918 and 1923).

Review of Literature

Ornithological literature contains few references to the food of Barrow's Golden-eyes. In Bent (*loc. cit.*) appears the following: "Dr. F. Henry Yorke (1899) records it as feeding on minnows and small fishes, slugs, snails, and mussels, frogs and tadpoles, in the way of animal food; he has also found in its food considerable vegetable matter, such as teal moss, blue flag, duckweed, water plantain, pouch-weed, water milfoil, water starwort, bladderwort and pickerel-weed". Apparently these remarks have reference to localities in the Eastern United States.

Dr. C. Cottam (1937) has presented a summary of food percentages of eighty-six specimens, from various localities not specified, as follows: Muskgrass and algae, .38; pondweeds, 8.19; wild celery, 1.57; misc. plants, 12.20; fish, 1.14; amphipods and isopods, 11.02; crabs and other decapods, 2.49; barnacles, .25; crustaceans, 3.95; blue mussel, 12.25; misc. pelecypods, .93; *Littorina*, 2.39; misc. gastropods, 3.11; caddisflies, 6.32; misc. insects, 30.08; misc. animals, 3.73. Total percentage of plants, 22.34 total percentage of animals, 77.66. Data representing the food of forty-six specimens in the above lot taken in British Columbia have been included in the present study by permission of the Bureau of Biological Survey, Washington, D.C.

Munro (1923) has recorded on a quantitative basis the food of fourteen specimens from Henderson lake, Vancouver island. These data are included in the following summaries.

Food Summaries

The following section summarizes the food eaten by the Barrow's Golden-eye as determined through the examination of 116 stomachs containing food material. Percentages refer to percentage volume obtained by segregating and estimating the individual items.

The material is assembled under two headings: (1) winter food on the coast, (2) food in the interior.

Winter Food of Barrow's Golden-eye on the Coast Region

Henderson lake is represented by a sufficient number of specimens to provide a picture of the food range throughout the winter and the data

for this locality are presented separately; other localities are grouped according to whether they represent specimens taken on fresh water or on the sea.

Henderson lake (mouth of Clements creek)

Number of specimens: November, thirteen; December, five; January, two; February, eight.

Salmon eggs. Fourteen specimens taken in November and December contained a total of 1,300 sockeye salmon eggs, 300 being the largest number in one stomach; two specimens taken on February 13, 1923, contained a few salmon egg cases.

Salmon flesh. Evidence that salmon flesh had been eaten was found in two specimens taken February 13, 1923.

Unidentified fishes. Bone fragments of small fishes were found in four specimens taken in January and February; in each case these formed a minor item of the total stomach contents.

Crustaceans. Three amphipods were present in a specimen taken February 13, 1923.

Mollusks. Fragments of blue mussel (*Mytilus edulis*) occurred in one specimen and four fresh-water snails (*Planorbis callioglyphus*) in another; both specimens were taken on February 13, 1923.

Caddis. Caddis larvae were detected in six stomachs taken in January and February; in two instances no other food was present.

Summary. Salmon eggs are the principal food during Novenber and December; there are six instances of caddis larvae, and three instances of small fishes being eaten; the marine items noted probably were taken just prior to the ducks' flight from the sea to freshwater.

Rivers on Vancouver Island

Number of specimens. Cowichan river, December, two; Chemainus river, December, one, January, four.

Salmon eggs. Fragments of salmon egg cases were contained in each of three specimens from the Cowichan river; in one Chemainus river specimen were fifty-five chum salmon eggs and a mass of salmon egg cases representing a much larger number.

Salmon flesh. Broken-down salmon flesh represented the entire contents of two specimens taken on the Chemainus river, January 30, 1932.

Mollusks. Fragments of marine gastropods were a minor item in a stomach containing salmon eggs; six whole *Littorina* and fragments of other mollusks formed forty per cent of the contents of another stomach.

Caddis. Caddis larvae and cases formed over half the contents of a well-filled stomach from a specimen taken on the Cowichan river, December 30, 1933.

Misc. vegetable matter. One bulrush seed, *Scirpus americanus*, and fragments of marine algae represented the only identifiable vegetable matter.

Summary. As at Henderson lake the most important food is salmon eggs; salmon flesh is second, and marine algae third in percentage volume.

Estuaries and salt water, Vancouver Island and Mainland Coast

Number of specimens. Bowen island, January, one, March, six; Horseshoe bay, January, one; Departure bay, March, one; Prince Rupert, March, one.

Herring, *Clupea pallasii.* Twelve herring eggs formed less than one per cent of the Departure bay specimen.

Mollusks. Shell fragments of blue mussel constituted the sole contents of seven, fifteen per cent of another, and was represented by a few fragments in other specimens. Gastropods of various species occurred in three stomachs, the following species being identified: *Littorina scutulata, Littorina sitchana, Columbella gausapata, Margarites pupilla, Thais* sp.

Crustaceans. Fragments of small crabs were detected in the Bowen island and Prince Rupert specimens.

Vegetable matter. Pieces of marine algae, totalling 2 cc., constituted twenty per cent of the contents of one, and sea lettuce (*Enteromorpha* sp.) represented fifty per cent of the total food in another stomach.

Summary. On salt water blue mussel and various gastropods are the chief food; marine algae is second in percentage volume; other items are of minor importance.

FOOD IN THE INTERIOR

Okanagan lake

January, three; March, 1; October, one; December, two.

Unidentified fishes. Unidentified fish remains were a minor item in one stomach.

Crayfish (*Potamobius klamathensis*). Crayfish formed the chief item in two well-filled stomachs.

Amphipods. One occurrence represented twenty-six per cent of the contents of a well filled stomach.

Caddis. In one specimen 302 caddis larvae cases constituted seventy-seven per cent of the contents of a full stomach and caddis occurred in another as a minor item.

Other aquatic insects. Corixidae, *Notonecta*, Dytiscidae, *Gyrinus* sp., Anisoptera larvae, and unidentified insect fragments constituted sixty-seven per cent of a well filled stomach. Insect remains including mayfly, stonefly and Coleoptera, occurred in two other specimens.

Mollusks. Mollusk fragments were a minor item in three specimens.

Vegetable matter. Potamogeton tubers and plant fibre formed in one case ninety-seven per cent, and in another ninety per cent of a full stomach. *Scirpus* and *Carex* seeds and Characeae were minor items detected.

Summary. Food taken on Okanagan lake listed in the order of importance comprises crayfish, pondweeds, aquatic insects, amphipods and mollusks.

Swan lake

September, one.

The contents of a single specimen consisted of comminuted vegetable matter exclusively of which filamentous algae and one seed of *Potamogeton heterophyllus* was identifiable.

Small alkaline ponds near Okanagan landing

April, eight; May, one; June, five; July, six; September, sixteen; October, one.

Sponge, *Porifera*. Sponge occurred as a small item in two stomachs.

Crustaceans. Amphipods (and probably other small crustaceans) were the chief item in five stomachs, representing in three cases ninety per cent or more, and in two cases fifty per cent or more, of the total contents. Another specimen contained a small amount of crustacean material.

Water mites, *Hydrachnidae*. Water mites were present in four stomachs.

Aquatic insects. Corixids were present in twenty-three, *Notonecta* in seven, odonate nymphs in fourteen, chironomid larvae in five, Haliplidae in seven, Dytiscidae in two and other Coleoptera in seven of the specimens examined. Caddis larvae occurred twice and stonefly nymph once.

Vegetable matter. Pondweeds including *Potamogeton pectinatus* and *Potamogeton pusillus*, both seeds and plant fibres, represented a large proportion of the plant material eaten and were present in eighteen stomachs. In one April specimen seeds of *P. pectinatus* represented ninety-eight per cent (3 cc.) of the stomach contents and in another

was the chief item present. *Carex* seeds occurred in six, *Scirpus* seeds in nine, and *Myriophyllum spicatum* seeds in five stomachs. Other plants represented by seeds were: *Ruppia* sp., *Zanichellia palustris*, *Spartina* sp., *Hordeum* sp., *Polygonum* sp., *Rumex* sp., *Chenopodium* sp., *Ranunculus* sp., *Prunus demissa*, *Rosa* sp., and *Hippuris* sp. *Chara* fragments and oogonia were noted in two specimens.

Mollusks. Shell fragments of snails were a minor item in three stomachs.

Summary. The most important food in the small ponds, upon which the young are raised, appears to be aquatic insects, particularly Odonata nymphs and Hemiptera. Caddis larvae occur less frequently than in larger lakes. Plant material, including the seeds of numerous aquatic and hydrophytic species, although present in most of the stomachs examined form about one-quarter (25.3 per cent) of the total food. No difference between the food of adults and that of well-grown young was detected.

Osooyos lake

May, two.

One full stomach contained eighty per cent insect material comprising forty-eight whole and fragments of eighty or more damselfly nymphs *Enallagma* sp., four other odonate nymphs, twelve or more caddis larvae, Corixidae, chironomid adults, pupae and larvae, Plecoptera nymph, *Haliplus* sp., and fifty or more *Sayomyia* larvae. The remaining nine per cent animal material consisted of bone fragment of an *Amblystoma*, a few *Hyalella azteca* and Hydrachnidae. Vegetable matter consisted of twenty-six seeds of *Potamogeton pectinatus* and seeds of another pondweed, *Scirpus occidentalis*, *Polygonum remosissimum*, algae and miscellaneous plant material.

A second specimen contained caddis larvae as the main item with odonate nymphs, Haliplidae larvae and miscellaneous insect material constituting seventy-eight per cent of the total. Other animal items were mollusks, water mites and amphipods; plant material represented sixteen per cent of the total.

White Lake, Similkameen Valley

June, one.

This specimen contained eighteen per cent animal matter, including fragments of mollusks, chironomid larvae, Orthoptera eggs, Plecoptera nymph, Carabidae, *Hydroporus* sp., and other aquatic and terrestrial beetles. Vegetable matter included seeds and plant fibre of *Ruppia maritima*, approximately 100 seeds of *Zanichellia palustris*, and 200 of *Potamogeton pectinatus*.

Pond, Nicola Valley

June, one.

Crustacean (probably amphipod) fragments represented seventy-five per cent of the total, the balance being made up of insect fragments including Diptera, caddis larvae and *Dytiscus* sp.

Paul Lake

May, three; June, two; November, two.

Caddis. Caddis larvae constituted the total contents of four, and were present in a fifth stomach, the numbers of insects in individual specimens being 3, 8, 10, 38, 48.

Odonata. Parts of dragonfly nymphs were the only item in two November specimens. Three complete damselfly nymphs and fragments of at least thirty others were the chief item in another stomach.

Other aquatic insects. Fragments of Corixidae were present in one stomach.

Mollusks. Broken up snail shells formed twenty-five per cent of the contents of one stomach.

Misc. vegetable matter. Excepting small quantities of vegetable debris in most of the specimens a single *Carex* seed was the only indication that vegetable matter had been eaten.

Summary. The food of five adults and yearlings taken in May and June and two young males taken in November consisted chiefly of aquatic insects; mollusks occurred once; there was no evidence that amphipods had been eaten although these crustaceans are particularly common in Paul lake.

Horse Lake

July, three; August, three.

Caddis. This item occurred in three stomachs.

Other aquatic insects. Mayfly nymphs occurred in three stomachs, chironomid larvae and larvae of a dytiscid beetle in each of two others.

Odonata. Twelve dragonfly nymphs were the exclusive food item in one specimen.

Corixidae. Water boatmen occurred in three stomachs, in one case constituting the entire contents.

Terrestrial insects. An ichneumon fly and small pieces of other terrestrial insects formed the entire contents of one stomach; in another fragments of unidentified insects constituted twenty per cent of the stomach contents.

Misc. vegetable matter. Five seeds each of *Sparganium* and *Carex* constituted two per cent of the food in one stomach; *Chara* and unidentified vegetable matter formed ten per cent of the contents of another and one seed of *Potamogeton pusillus* was present in a third stomach.

Summary. The food of six Barrow's Golden-eye, from three weeks to two months old, at Horse lake was chiefly insects, both aquatic and terrestrial species being taken. Caddis larvae (an important item in the diet of adults in most localities) was eaten less than were water boatmen and terrestrial insects. This agrees with field observations which showed young golden-eyes feeding from the surface of the water to a greater extent than did the adults. Vegetable matter and mollusks apparently are not important items in the food of the young, no trace of amphipods was detected.

105 Mile Lake

August, two.

The stomach contents of a yearling comprised terrestrial insects 50 per cent, water boatmen 20 per cent and mollusk shell fragments 30 per cent. One *Sparganium* seed had also been eaten. Comminuted amphipods represented 95 per cent of the food eaten by a full-grown young female; the remaining items being one sow bug, 3 per cent, and corixid fragments, 2 per cent.

Mirage Lake

August, three.

Three yearling females had eaten water boatmen, adults and nymphs, exclusively.

Anthony Lake

July, two.

The chief item in one specimen was comminuted amphipods, 98 per cent, the remainder being water boatmen fragments and one *Myriophyllum* seed; in the other caddis represented 94 per cent and water boatmen 1 per cent; the remainder comprised approximately fifty seeds of *Eleocharis palustris* and one *Polygonum* sp. seed.

White Horse Lake

July, one.

Caddis totalled 95 per cent of the stomach contents, the remainder being odonate nymph and water boatmen 4 per cent and two seeds of *Potamogeton pectinatus*, 1 per cent.

Westwick Lake

July, one.

A downy young several days old contained caddis 75 per cent, dytiscid beetle 20 per cent and filamentous algae 5 per cent.

Summary. The food of four yearling females and five juveniles taken at five small lakes in the Cariboo region was chiefly aquatic insects with water boatmen of first and caddis of second importance. Amphipods had been eaten in the two lakes where these are known to occur. Fairy shrimps (*Branchinecta* sp.) were not found in any of the three specimens collected at Mirage lake where these crustaceans are abundant.

GENERAL SUMMARY AND DISCUSSION

The food item of chief economic importance on the coast is salmon eggs, which would seem to be the sole food in some places during the period of the salmon run. This was the case at Henderson lake in November and December, 1922.

On all salmon streams a large number of eggs are not permanently covered during the spawning process and these drift downstream and lodge here and there in the stream bed. Some of these eggs may later be covered with gravel, and, if not injured during their progress downstream, may successfully hatch. Probably the larger number of these drifting eggs do not become covered and because of exposure to light, mechanical injury, or some other cause, lose their vitality. In the early part of the spawning period they are rose coloured and semi-transparent; later those that have lost their vitality turn pale pink in colour and become opaque. Early in the season most of the eggs found in the gullets of golden-eyes are clear; no doubt many are still vital and capable of producing fry. Later most, if not all, the eggs consumed are in various stages of opaqueness and are considered to be dead eggs. The destruction of the clear eggs in the early part of the salmon run may represent a drain upon salmon production but of what extent it seems impossible to estimate.

Remains of small unidentified fish occurred in several stomachs; it is possible that trout and salmon fry are eaten in some localities; caddis larvae are an important food.

Salmon eggs may also be taken in the interior of the province although no evidence of this is available. The present data indicate that elsewhere than on the coast the Barrow's Golden-eye is related to the fisheries only insofar as it may be a food competitor of trout. Specimens taken in the interior had been feeding chiefly on aquatic insects, crustaceans and

vegetable matter (animal matter ninety-six per cent, vegetable matter four per cent).

It has been recommended by anglers that the Barrow's Golden-eye population of Paul lake be destroyed on the grounds that the ducks eat trout fry and that they are competitors of Kamloops trout for food. Paul lake was barren of fish life until Kamloops trout were successfully introduced some years ago. Since that time the lake has developed as an angling resort and in this development financial investments of various kinds were made. Those interested believe that the removal of possible predators and food competitors of trout would improve the fish population and increase the financial return on investments. To the author the success of such an undertaking seems doubtful. The data available on the food of Barrow's Golden-eye do not indicate predation; as to their being food competitors of trout undoubtedly this is true. It is true also that practically all other species of birds which nest along the lake shore feed to some extent upon aquatic insects. Spotted Sandpipers, swallows, Yellow-throats, Yellow Warblers, Cedar Waxwings and other birds are competitors of trout for food to the extent to which they consume midges, caddisflies, damselflies and other insects. This statement is substantiated by field observations.

FOOD PERCENTAGES BARROW'S GOLDEN-EYE

Locality	No. of specimens	Salmon eggs	Salmon flesh	Sculpins	Unidentified fishes	Crustaceans	Caddis	Other insects	Mollusks	Misc. animals	Misc. vegetable matter
Henderson lake	28	54.45	16.42	....	7.75	.18	14.11	....	3.51	....	3.58
Vancouver I. rivers	7	32.00	25.00	....	....	....	11.42	....	6.43	....	25.15
Estuaries	10	....	....	....	....	8.40	....	....	89.10	....	2.40
Okanagan lake	7	....	....	.28	....	31.57	11.14	13.29	.43	....	43.29
Swan lake	1	....	....	....	....	....	....	....	....	....	100.00
Pond, Okanagan	37	....	....	....	....	11.41	7.24	58.87	.32	1.20	20.96
Osooyos lake	2	....	....	....	....	2.00	39.50	39.50	.50	7.50	11.00
White lake	1	....	....	....	....	....	....	16.00	1.00	2.00	81.00
Pond, Nicola	1	....	....	....	....	75.00	1.00	24.00	....	....	....
105 Mile lake	2	....	....	....	....	47.50	....	36.00	15.00	1.50	....
Horse lake	6	....	....	....	....	....	15.00	83.00	....	....	2.00
Paul lake	7	....	....	....	....	....	58.57	37.86	3.57	....	....
Mirage lake	3	....	....	....	....	....	....	100.00	....	....	....
Anthony lake	2	....	....	....	....	49.00	47.50	1.00	....	....	2.50
White Horse lake	1	....	....	....	....	....	95.00	4.00	....	....	1.00
Westwick lake	1	....	....	....	....	....	75.00	20.00	....	....	5.00

Barrow's Golden-eye and the other birds mentioned are valuable in themselves and their destruction would mean a distinct loss to the community not only from the standpoint of national economy but from the aesthetic point of view.

Considered solely from the sportsmen's point of view a good case can be made for the argument that the ducks are valuable in the same sense as trout are valuable, that is to say, as objects of sport and food.

The Barrow's Golden-eye is regarded in the interior of British Columbia as a game bird of minor importance. Nevertheless in some localities, for a short time in the early part of the hunting season, this duck may represent a considerable fraction of the hunter's bag. In the interior its flesh is palatable, but on coast waters the flesh becomes tainted from the diet of salmon eggs and marine food, consequently the duck is not hunted or used as food to the same extent as in the interior. Figures are not available but it seems likely that (in proportion to relative numerical abundance) a greater number of Barrow's Golden-eye are killed by hunters than is the case with more common species of ducks. When disturbed from a pond they have a habit of circling, usually passing close to anyone standing on the shore, so that the hunter has an advantage which he does not have in the case of other ducks which fly straight away.

AMERICAN GOLDEN-EYE, *GLAUCIONETTA CLANGULA AMERICANA*

LIFE-HISTORY

Distribution

The American Golden-eye is extensively distributed in North America, having a summer range which includes most of the timbered portions of northern Canada (except in British Columbia) and a winter range on the Great Lakes, the Atlantic and Pacific coasts (fig. 4). It is a much more abundant species than Barrow's Golden-eye. An old world form of the species breeds in Northern Europe and Asia.

Four instances of the American Golden-eye nesting in British Columbia have been recorded (Munro, 1935), two of these records being based solely on the presence of mated pairs during the nesting season. It is quite possible that it nests regularly in the northern part of the province, although this fact has not been established. The species nests commonly in Alberta from the Edmonton region north and in the Yukon and the Northwest Territories of Canada. In British Columbia it is a common migrant, appearing spring and fall on many of the inland waters. It seems reasonable to conclude that many of these birds are en route to

and from nesting grounds which lie to the northeast. The chief wintering ground is on the coast where the species shows preference for a salt water habitat.

Seasonal Movements and Numerical Status

In the interior of British Columbia the two species of golden-eye appear at about the same time in spring (usually in early March). Early arrivals frequent the larger lakes, which may have been free of ice all winter and in any case are open before the small ponds. In these first spring flocks the American Golden-eye usually predominate and in some the less common species may not be represented. Later in the spring the two species associate on the ponds and small lakes—the courting grounds of Barrow's Golden-eye. For a time the American Golden-eye may continue in the majority as at Napier lake, April 19, 1933, where a census showed sixty *americana* and sixteen *islandica*, and at Rollings lake, April 24, 1937, where the count was fifteen *americana* and twelve *islandica*.

These flocks contain both adults and yearlings. As pointed out earlier it is difficult to distinguish in the field between yearlings of the two species, particularly when a large number of birds are to be examined. Thus it frequently proved impossible to decide what percentage of yearlings in these mixed flocks was *americana*. Under favourable field conditions comprising nearness to the birds and good visibility, it is possible with the aid of binoculars to identify yearlings specifically. At these times it was observed that the number of adult male *americana* equalled the total number of adult females, yearling females and yearling males of the species (in flocks of Barrow's Golden-eye it is usual in the spring to find a minority of adult males). If this condition is of regular occurrence, it would suggest that all the yearling American Golden-eyes do not accompany the adults to their breeding grounds as apparently is the case with Barrow's Golden-eye. Observations on the Tlell river, Queen Charlotte islands, suggest that yearlings may migrate later than do the adults; on the other hand it is not improbable that numbers of them may spend the summer on salt water. Counts taken near the outlet of the Tlell river in May, 1935, showed that the population changed from day to day which would indicate a migratory movement amongst some at least of its members. On the other hand, American Golden-eyes are not commonly seen in the interior at so late a date.

Daily record of American Golden-eye, Tlell river, 1935:

May 2—50	May 14—16
" 3—30	" 15— 7
" 4—66	" 26—24
" 10—60	" 20—14

The spring migration from the coast to the breeding grounds (as observed in the southern interior of British Columbia) covers the period from early March to late April. The following counts were made by R. M. Robertson on the Thompson river at Kamloops during March, 1938: 4, (28), 5, (24), 7, (16), 8, (21), 10, (30), 11, (30). It is unusual to find birds in May and latest records available are May 8, 1928, of a yearling male and one yearling female near Oliver; May 29, 1938, two yearling males near Vernon. Flocks of adults, usually accompanied by yearlings, are still on the coast long after the species has become common in the Okanagan and Nicola districts, for example: Morris creek, April 10, 1936, (40); Cultus lake, April 17, 1935, (8); Esquimalt lagoon, March 28, 1938, (62).

Laing (1925) reports seeing two or three adult males at Juneau, Alaska on March 9, and three at Uyak bay, Kodiak island, on March 31. Other golden-eyes at Unalaska and Adak island were not satisfactorily identified.

Swarth (1936) records it as a migrant of regular occurrence in spring but in small numbers in the Atlin district. Earliest arrivals are given as April 28, 1934; May 6, 1935.

It seems probable that adult males remain all summer near their nesting ground, although no definite information on this point is available. At any rate, adult males, accompanying females, young of the year, and a few yearlings, again appear in the interior of British Columbia in the late fall. Dates of arrival on Swan lake near Vernon in recent years are November 11, 1932 (50), November 1, 1933 (10). Should mild weather continue, flocks may remain for some time. Thus on December 18, 1937, a total of eighty-nine was observed on Woods lake and Duck lake. The species begins to appear on coast waters at about the same time in November; a flock of ten was noted on Esquimalt lagoon, November 16, 1936.

Winter populations in the interior are usually small, restricted to a few birds which frequent rapid stretches of rivers and the larger lakes which remain free of ice. At the north end of Okanagan lake, the American Golden-eye was of regular occurrence during the winters from 1911 to 1919; throughout the winter of 1917-1918, eight was the largest number seen in one day. Subsequently it became scarce and some winters none was seen. More recently small numbers have again appeared on this lake. It is reported to be "very common" in winter on the Arrow lakes but enumerations are not given (Kelso, 1926). It is believed that over ninety-five per cent of the winter population is to be found on the coast where the species is common on all sheltered waters.

The summer population in the interior of British Columbia is limited

to an occasional female and brood. As stated earlier, only four cases of nesting have been recorded and not all of these records are entirely satisfactory. Nothing is known concerning a salt-water, summer population of non-breeding birds, if such exists.

Courtship and Nesting

The sexual displays of the two species of golden-eye are of similar character and early manifestations by adult males take place during the winter. Thus at Departure bay on February 11, 1938, several males were observed at different times swimming with the neck outstretched on the water and the bill pointing slightly upward, so that the chin was raised above the surface. After swimming for a short distance in this position the bird would dive and swim towards another male; usually after such a performance the male which had been the pursuer would stand upright and shake his wings, curving them forward in front of his body. At the same place during the period February 27 to March 31 courting was actively pursued by the members of a flock numbering thirty of which males were in the majority. The actions included various modifications of the quick backward jerk of the head; the back kick, displaying orange feet against white flanks; the rush across the surface with neck outstretched; the sudden dive, reappearance and copulation. The courtship as observed in March is described in further detail by Munro and Clemens (1931). Courtship is continued during the period in spring when the birds are making a short stay in the interior while en route to their nesting grounds.

The author has not studied the American Golden-eye on its nesting ground. The nesting habits of the two species are reported to be similar; both commonly occupy a site in a hollow tree and the males leave the females before the eggs are hatched. Mr. T. E. Randall has found it nesting at Sylvan lake, Gull lake and other places in southern Alberta. In a personal communication he states: "The great majority of the nests found by me have been in old nest-holes of the Pileated Woodpecker. Failing a supply of these, hollow stumps are used and I know of five places where a chimney is used."

"Nesting sites are used year after year and I found a stump west of Rochester that held sixteen nests which filled the hollow to a depth of five feet. Strangely enough, in six of the nests the eggs had not hatched and in one or two of the lower nests they were so discoloured by age that the green colouring of the shell was scarcely distinguishable. Another tree in the Athabasca district held three new nests, there being five old holes and one new one which contained four eggs of the Pileated Woodpecker. The American Golden-eye lays from nine to sixteen eggs but

this number is sometimes exceeded and I once found twenty-three in a woodpecker's hole."

Details of the subsequent behaviour of females and young are not available. Yearlings apparently do not breed although, like yearling Barrow's Golden-eye they perform parts of the courtship display. Sometimes a yearling male and female remain together and act generally as if paired.

FOOD STUDIES OF AMERICAN GOLDEN-EYE

Feeding Habits

Flocks of large size may assemble when feeding conditions are particularly favourable as, for example, on Esquimalt lagoon, February 25, 1936 (150 estimated), Departure bay, March 12, 1930 (500 estimated). At other times it is more usual to see single birds or a few individuals feeding together. The concentration of 500 at Departure bay followed a spawning of herring at the head of the bay as recorded by Munro and Clemens (*loc. cit.*). The ordinary winter population of Departure bay, which is typical of similar populations elsewhere, is set forth in the following table of enumerations during February and March, 1929. At this time the golden-eyes were feeding on shore-crabs and gastropods.

Date	No. adult males	No. females
February 25.....	2	0
" 26.....	3	1
" 27.....	3	1
" 28.....	10	0
March 1........	6	0
" 2........	8	7
" 11........	3	0
" 12........	12	7
" 13........	10	20

When diving in deep water this species appears to submerge more quickly than other diving ducks; the birds turn almost at a right angle to the swimming position and, with tail bent slightly backward, go almost straight down.

The behaviour when feeding on salmon eggs is identical with that of the Barrow's Golden-eye, Munro (1923). The eggs are taken from the bottom of the stream in shallow water or from the eddies where drifting eggs accumulate. No evidence of eggs being dug from gravel has been obtained. On any salmon stream there is some movement of birds during the greater part of the day between the sea or lake and the upper

reaches of the stream but the main flights are in the morning and evening. Apparently all the gold-eyes which feed on the salmon streams spend the night on the sea or on adjacent lakes.

Review of Literature

In the somewhat extensive literature on the American Golden-eye are numerous references to food on a qualitative basis. A summation of data by Bent (1925) mentions mussels, mollusks and seeds of eelgrass, as marine food eaten on the Atlantic coast; mussels, crabs, marine worms and salmon flesh are mentioned for the Pacific coast. Seeds of various aquatic plants, insect larvae, fish spawn and crayfish are recorded as food eaten on fresh water.

This author also makes the following statement on the authority of W. L. Dawson, 1909 (The Birds of Washington): "on inland waters it may often be seen in the rapids chasing young trout or other small fishes". It is not stated whether the observation was verified by stomach analyses.

Cottam (1937) has presented a summary of food percentages of 441 specimens from various localities not specified, as follows: Muskgrass and algae, .80; pondweeds, 8.62; wild celery, 3.42; misc. plants, 13.25; fish, 3.16; amphipods and isopods, 5.00; crab and other decapods, 22.57; barnacles, .48; misc. crustaceans, 4.37; blue mussel, 2.53; *Paphia*, etc.. .19; oysters and scallops, .11; misc. pelecypods, 1.37; *Littorina*, .52; misc, gastropods, 4.99; caddisflies, 12.32; misc. insects, 15.66; echinoderms, .02; misc. animals, .62. Total percentage of plants, 26.09; total percentage of animals, 73.91. Data representing the food of thirty-one specimens in the above lot taken in British Columbia have been included in the study by permission of the Bureau of Biological Survey, Washington,D.C.

Apparently the relation of the European Golden-eye *Glaucionetta clangula clangula* to the fisheries in the British Isles has not been established. Berry (1935) lists various food items including fresh-water mollusks, crustaceans, larvae of aquatic insects, aquatic plants, small fish not exceeding two inches in length, and tadpoles. The author also states that "the European Golden-eye is said to dig up spawning redds with its feet and then drop downstream to swallow the spawn washed out". This behaviour has not been observed on British Columbia salmon streams. Berry also quotes an authority for the statement that in Switzerland golden-eyes eat Miller's thumb (*Cottus gobio*). His conclusions are expressed as follows: "These birds should not, therefore, be condemned until definite knowledge of their usual diet in any given locality has been ascertained. Nevertheless they are at all times to be regarded with grave suspicion, for at least one specimen has been shot on an English river (quoting) "with salmon spawn oozing from its bill".

Food Summaries

The following section presents a summary of the food eaten by 80 American Golden-eyes taken during the winter and spring months on the coast and in the interior of British Columbia. The data are assembled under six headings. (1) Cowichan river, (2) Other rivers and lakes on Vancouver island, (3) Estuaries and Salt water, (4) Tlell river, Queen Charlotte islands, (5) Okanagan lake, (6) Alkaline pond, Okanagan valley.

Cowichan river

Number of specimens: December, thirteen; January, fifteen; March, one.

Lamprey (*Entosphenus tridentatus*). One lamprey measuring 65 mm. was found in the stomach of a specimen taken on January 3, 1934.

Salmon eggs. Sixteen specimens taken between December 26, 1933, and January 10, 1934, contained salmon eggs varying in amount from a few fragmentary egg cases in several stomachs to a large amount, comprising 150 whole eggs plus a quantity of partly digested egg cases, in another specimen. The total number of eggs (by computation) in the sixteen stomachs was 402; all these eggs were opaque.

Salmon flesh. Small fragments of salmon flesh were noted in three specimens taken December 30, January 7 and January 10.

Unidentified fishes. Bone fragments of small fishes occurred in four specimens. This material was too much abraded to permit further identification.

Earthworm, Oligochaeta. One earthworm was a minor item in a well-filled stomach.

Crustaceans. Each of three specimens, which were shot while flying up the river from the sea, contained fragments of crab, identified as *Hemigrapsus nudus* and *Hemigrapsus oregonensis*.

Mollusks. One of the specimens mentioned under the heading crustaceans also contained a number of small gastropods, including six *Littorina scutulata*; mollusk shell fragments were noted in another specimen.

Insects. Caddis larvae and cases were represented in eighteen of the twenty-nine specimens examined, by quantities varying from fragments of several to a maximum of twenty-one whole insects; in one case this item formed ninety per cent of the entire stomach content. Alder fly (*Sialis*) larvae were of next importance in terms of percentage volume, ten being found in one, and thirty-three in another specimen. Other insects taken were: Dipterous larvae in two specimens and one instance each of beetle larva (Dytiscidae), cranefly

larva (Tipulidae), mayfly nymph, *Ephemerella*, and caterpillar (Lepidoptera). The March specimen contained 12 cc. of insect food all *Simulium* larvae and pupae except for one chironomid and one caddis larva.

Misc. vegetable matter. Seeds of various plants occurred as a minor item in nine specimens, the species identified being: Knotweed (*Polygonum paronychea*), Brome grass (*Bromus hordeaceus*) and Bulrush (*Scirpus americanus*). The other stomachs contained comminuted vegetable matter not identified; in one instance this was the exclusive, and in another the chief item.

Summary. Salmon eggs are the food of first importance and insects are second in terms of percentage volume, while vegetable matter is of some importance. Remains of small fishes may represent either marine or freshwater species and the data are valuable only as indicating that the American Golden-eye eats small fish. Mollusks and crustaceans, representing food taken in the sea, and other items mentioned are of slight importance in the specimens examined.

Other rivers and lakes on Vancouver island

Localities and numbers of specimens: Goldstream river, December, one; Chemainus river, November, one; December, one; Quamichan lake, December, one; Henderson lake, November, four, February, one.

Salmon eggs. Seven chum salmon eggs were the sole item in the Goldstream river specimen; this food also was taken by the two specimens from Chemainus river, and by one from Henderson lake.

Sculpin (*Cottus asper*). The Quamichan lake specimen had eaten seven sculpins measuring 26 to 43 mm.

Unidentified fishes. One of the Chemainus river specimens contained a few bone fragments of a small fish.

Mollusks. Two Henderson lake specimens contained pieces of blue mussel, the remains of an earlier feeding on the sea.

Caddis. Two caddis larvae were a minor item in one of the Chemainus river specimens.

Summary. The small number of specimens available reflect the same general food range as that pertaining to the Cowichan river. The identification of the sculpin, *Cottus asper*, as the sole item in the stomach contents of a specimen shot on a lake is of interest.

Estuaries and salt water (Vancouver island and Mainland coast)

Localities and numbers of specimens: Horseshoe bay, January, one; Cowichan flats, January, one, December, one; Departure bay, January, two, February, three, March, one.

Herring. It was noted by observation at Departure bay and Nanoose bay that American Golden-eyes were diving for herring eggs in company with a large number of other water fowl. No specimens were collected at this time.

Crustaceans. Small crabs of several species had been eaten by seven of the nine specimens examined. The species identified were: *Hemigrapsus oregonensis*, *Hemigrapsus nudus* (Dana), *Lophopanopeus bellus* (Stimpson). In one case *Hemigrapsus oregonensis* in fragments was the sole item and comprised 12 cc. of food; eight whole crabs were found in another and seven in a third specimen.

Marine worms, Polychaeta. Jaws of a large polychaete were detected in one specimen.

Mollusks. Blue mussel was the sole item in one, and small gastropods were found in four other specimens. In one instance gastropods had been taken exclusively, the species identified being *Littorina scutulata*, *Alectrion mendicus* and *Thais lamellosa*.

Summary. On the sea crustaceans and mollusks are the chief food. During the spawning operations of herring, American Golden-eyes may assemble in large flocks and for a few days feed on herring ova.

Tlell river, Queen Charlotte islands

Number of specimens: May, three.

Sculpin. The specimens contained fragments of sculpins, which in one case was identified as *Cottus asper*.

Crustaceans. Isopods and amphipods constituted the chief item in two, and were represented in a third stomach.

Caddis. Caddis larvae were a minor item in one stomach.

Okanagan lake

Number of specimens: November, one; December, eight; January, thirteen; February, five; March, two.

Sculpin (*Cottus asper*). Fragments of cottids were detected in eighteen specimens. These fish are captured under stones in shallow water in the same manner as crayfish are taken (Munro 1918).

Unidentified fishes. This item comprised fragmentary fish remains which in one case was identified as cyprinoid.

Crustaceans. On numerous occasions American Golden-eyes were seen capturing crayfish (*Potamobius klamathensis*) in the shallow waters. The importance of this food as suggested by field observation is borne out by the examination of stomach contents which showed it

to be the major item in several specimens with a total of twenty-four occurrences. There were fifteen occurrences of other crustaceans most of which probably represented *Gammarus limnaeus* and *Hyalella azteca*.

Insects. Encased caddis larvae are the most important insect food in number of occurrences with sixteen recorded; in one instance 271 larval cases of *Brachycentrus* sp. constituted eighty-eight per cent of a full stomach. Other occurrences were Ephemeridae (6), Odondata (9), Corixidae (2) and Coleoptera (2).

Mollusks. Twenty-seven occurrences indicate the importance of mollusks as food; *Lymnaea vahlii* appeared the most frequently and *Eluminicola* sp. and Unionidae also were reported. Much of the mollusk material was in the form of debris.

Misc. vegetable matter. Plant material was present in twenty-two stomachs, in only one constituting more than fifty per cent, and in the majority representing less than five per cent of the total contents. Characeae was reported from five, *Hordeum* sp. from one, pondweeds from two and *Carex* seeds from four specimens.

Small pond near Okanagan Landing

Number of specimens: April, one.

This specimen contained sixty-nine per cent insect fragments, chiefly odonate nymphs but including also Corixidae, Chironomidae, Coleoptera and caddis; two per cent mollusk fragments and nineteen per cent vegetable matter composed of plant fibre and sixteen seeds of *Potamogeton pectinatus*, two seeds of *Scirpus* sp., floral fragment of *Rumex* sp. and one seed of *Eleocharis* sp.

Summary. The percentages of animal and vegetable matter in thirty specimens were 84.5 and 15.5 per cent respectively. In numbers of occurrences mollusks are the food of first importance, crayfish second, insects third and amphipods fourth. One specimen collected on an alkaline pond had eaten insects, crustaceans, mollusks and plant material.

GENERAL SUMMARY AND DISCUSSION

The winter food of the American Golden-eye on coast waters appears to be substantially the same, under similar conditions of time and place, as that of Barrow's Golden-eye. While on fresh water both species feed upon salmon eggs, insect larvae, and occasionally small fish. On salt waters they eat crustaceans and mollusks and, for a short time, herring ova.

The American Golden-eye is much the more abundant of the two species and consequently is of the greater economic importance. The

question of the effect on salmon production by the consumption of salmon ova was discussed in the general summary in the section "Food Studies of Barrow's Golden-eye". In the author's opinion this predation does not cause an appreciable drain and it seems reasonable to assume that for the loss suffered there is compensation in the value of the ducks.

The value of the American Golden-eye as an object of sport in British Columbia is probably less than the value of the rarer species. The former is not present in the interior at the time the hunting season opens and may not arrive until after the small sloughs, where much of the hunting is done, are frozen over. Consequently its fall and early winter habitat is largely restricted to rivers and the larger lakes. On the lakes it has a better chance of survival than has Barrow's Golden-eye on the small ponds earlier in the season. As stated earlier, golden-eyes are not commonly hunted on the coast for food. In spite of these limitations the species is of economic value, perhaps more so in the general region of its nesting grounds in the north and the east than in British Columbia.

Contrary opinions, both as to the effect of predation by golden-eyes and as to the value of these ducks as game birds, have been expressed to justify the undertaking of control measures. It is unfortunate that any control measures which might be undertaken would have to include both species because of the difficulty in distinguishing them, particularly females and yearlings, a difficulty that would amount to impossibility as far as the majority of persons are concerned.

The breeding range of the American Golden-eye is extensive and because of its northern situation the species is not subject to many of the vicissitudes connected with the propagation of the more southern nesting

FOOD PERCENTAGES, AMERICAN GOLDEN-EYE

Locality	No. of specimens	Salmon eggs	Salmon flesh	Sculpins	Unidentified fishes	Crustaceans	Caddis	Other insects	Mollusks	Misc. animals	Misc. vegetable matter
Cowichan river.....	29	41.41	4.14	.....	.59	5.34	31.38	6.10	2.83	.55	7.66
Other rivers & lakes on Vancouver I..	9	44.11	22.22	11.11	.....	.....	.34	.....	22.22	.....	.....
Estuaries and Salt water..........	9	.....	.....	.....	.....	83.56	.....	.....	16.44	.....	.....
Tlell river, Queen Charlotte Islands.	3	.....	.....	38.34	.....	60.00	1.66	.....	.....	.....	.....
Okanagan lake....	29	.....	.....	7.11	.41	39.31	7.62	2.34	32.22	.79	10.20
Pond, Okanagan...	....	.....	.....	.....	.....	10.00	8.00	61.00	2.00	....	19.00

ducks. For this reason and because of its general abundance there is no immediate danger of any serious reduction in numbers. The situation in respect to Barrow's Golden-eye is quite different. The breeding range is comparatively small and includes much of the settled regions of British Columbia where young birds are shot for food and sport early in the hunting season. Nowhere does the species occur in numbers comparable to those of the American Golden-eye and summer populations may be reduced by drought as is the case with other southern nesting ducks. Thus any general project of control might seriously reduce the population of Barrow's Golden-eye.

BARROW'S GOLDEN-EYE

NUMBER OF SPECIMENS AND FOOD PERCENTAGES

Henderson lake (28)

	Occ.	Av. Per cent Vol.
Salmon eggs	16	54.45
Salmon flesh	5	16.42
Unidentified fishes	3	7.75
Amphipods	1	.18
Caddis	6	14.11
Gastropods	1	1.72
Blue mussel	1	1.79
Marine algae	1	3 58

Rivers on Vancouver island (7)

	Occ.	Av. Per cent Vol.
Salmon eggs	4	32.00
Salmon flesh	2	25.00
Caddis	1	11.42
Gastropods	2	6.43
Misc. Vegetable matter	2	3.72
Marine algae	2	21.43

Estuaries and salt water—Vancouver island and mainland coast (10)

	Occ.	Av. Per cent Vol.
Herring eggs	1	.10
Crab	2	8.40
Gastropods	3	17.10
Blue mussel	9	72.00
Marine algae	1	2.40

Okanagan lake (7)

	Occ.	Av. Per cent Vol.
Sculpin	2	.28
Crayfish	2	27.86
Amphipods	1	3.71

Corixidae, Notonectidae	1	3.43
Odonata	2	6.57
Caddis	2	11.14
Other aquatic insects	3	3.29
Mollusks	4	.43
Pondweeds	4	39.43
Misc. Vegetable matter	5	3.86

Swan lake (1)

	Occ.	Av. Per cent Vol.
Misc. Vegetable matter	1	100.00

Alkaline ponds near Okanagan Landing (37)

	Occ.	Av. Per cent Vol.
Amphipods	9	11.41
Terrestrial insects	9	.66
Corixidae and Notonectidae	28	19.81
Odonata	22	18.27
Caddis	6	7.24
Other aquatic insects	35	20.13
Mollusks	3	.32
Misc. Animals	13	1.20
Pondweeds	18	5.67
Misc. Vegetable matter	35	15.29

Osooyos lake (2)

	Occ.	Av. Per cent Vol.
Amphipods	2	2.00
Corixidae	1	.50
Odonata	2	27.50
Caddis	2	39.50
Other aquatic insects	2	11.50
Misc. Animals	2	7.50
Mollusks	1	.50
Pondweeds	1	2.00
Misc. Vegetable matter	1	9.00

White lake (1)

	Occ.	Av. Per cent Vol.
Terrestrial insects	..	0
Aquatic insects	..	16
Misc. Animals	..	2
Mollusks	.	1
Pondweeds	..	50
Misc. Vegetable Matter	..	31

Pond, Nicola valley (1)

	Occ.	Av. Per cent Vol.
Amphipods	..	75
Corixidae	..	1
Caddis	..	1
Other aquatic insects	..	23

Paul lake (7)

	Occ.	Av. Per cent Vol.
Corixidae	1	.72
Odonata	3	37.14
Caddis	5	58.57
Mollusks	1	3.57

Horse lake (6)

	Occ.	Av. Per cent Vol.
Corixidae	3	25
Odonata	1	16.67
Caddis	3	15
Other aquatic insects	3	21.33
Terrestrial insects	2	20
Misc. Animals	1	0
Pondweeds	1	0
Misc. Vegetable matter	2	2

105 Mile lake (2)

	Occ.	Av. Per cent Vol.
Amphipods	1	47.50
Crustaceans	1	1.50
Terrestrial insects	1	25 00
Corixidae	2	11.00
Mollusks	1	15.00

Mirage lake (3)

	Occ.	Av. Per cent Vol.
Corixidae	3	100.00

Anthony lake (2)

	Occ.	Av. Per cent Vol.
Amphipods	1	49.00
Corixidae	2	1.00
Caddis	1	47.50
Misc. Vegetable matter	1	2.50

White Horse Lake (1)

	Occ.	Av. Per cent Vol.
Corixidae	..	2.00
Caddis	..	95.00
Other aquatic insects	..	2.00
Misc. Vegetable matter	..	1.00

White Horse Lake (1)

	Occ.	Av. Per cent Vol.
Caddis	..	75.00
Other aquatic insects	..	20.00
Misc. Vegetable matter	..	5.00

AMERICAN GOLDEN-EYE

NUMBER OF SPECIMENS AND FOOD PERCENTAGES

Cowichan river (29)

	Occ.	Av. Per cent Vol.
Salmon eggs	16	41.41
Salmon flesh	3	4.14
Unidentified fishes	4	.59
Crabs	2	5.34
Caddis	18	31.38
Other aquatic insects	6	6.10
Mollusks	2	2.83
Misc. Animals	3	.55
Misc. Vegetable matter	9	7.66

Other rivers and lakes on Vancouver island (9)

	Occ.	Av. Per cent Vol.
Salmon eggs	4	44.11
Salmon flesh	2	22.22
Sculpin	1	11.11
Caddis	1	.34
Blue mussel	2	22 22

Estuaries and salt water—Vancouver island and mainland coast (9)

	Occ.	Av. Per cent Vol.
Crabs	8	83.56
Blue mussel	1	11.11
Gastropods	3	5.33

Tlell river, Queen Charlotte islands (3)

	Occ.	Av. Per cent Vol.
Sculpin	2	38.34
Crustaceans	3	60.00
Caddis	1	1.66

Okanagan lake (29)

	Occ.	Av. Per cent Vol.
Sculpin	17	7.11
Unidentified fishes	6	.41
Crayfish	24	34.52
Amphipods	15	4.79
Caddis	16	7.62
Other aquatic inscets	22	2.34
Mollusks	27	32.22
Misc. Animals	2	.79
Pondweeds	2	1.82
Misc. Vegetable matter	21	8.38

Alkaline pond near Okanagan Landing (1)

	Occ.	Av. Per cent Vol.
Amphipod	..	10.00
Caddis	..	8.00
Other aquatic insects	..	61.00
Mollusks	..	2.00
Pondweeds	..	10.00
Misc. Vegetable matter	..	9.00

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TO BE INSERTED BETWEEN PAGES 314 AND 315
TRANSACTIONS OF THE ROYAL CANADIAN INSTITUTE
VOL. XXII, PART 2, 1939.
PAPER BY J. A. MUNRO

BILL OUTLINES OF AMERICAN AND BARROW'S GOLDEN-EYE

Clangula islandica: **(1) No. 4743, ad. ♂, (2) No. 144, yearling ♂, (3) No. 4702, ad. ♀, (4) No. 3500, (5) No. 4899, variation in young ♂.**

Clangula americana: **(6) No. 4276, ad. ♂, (7) No. 2923, yearling ♀ (J.A.M. coll.), (8) No. 10464. ad. ♀ (Can. Nat. Mus. coll.).**

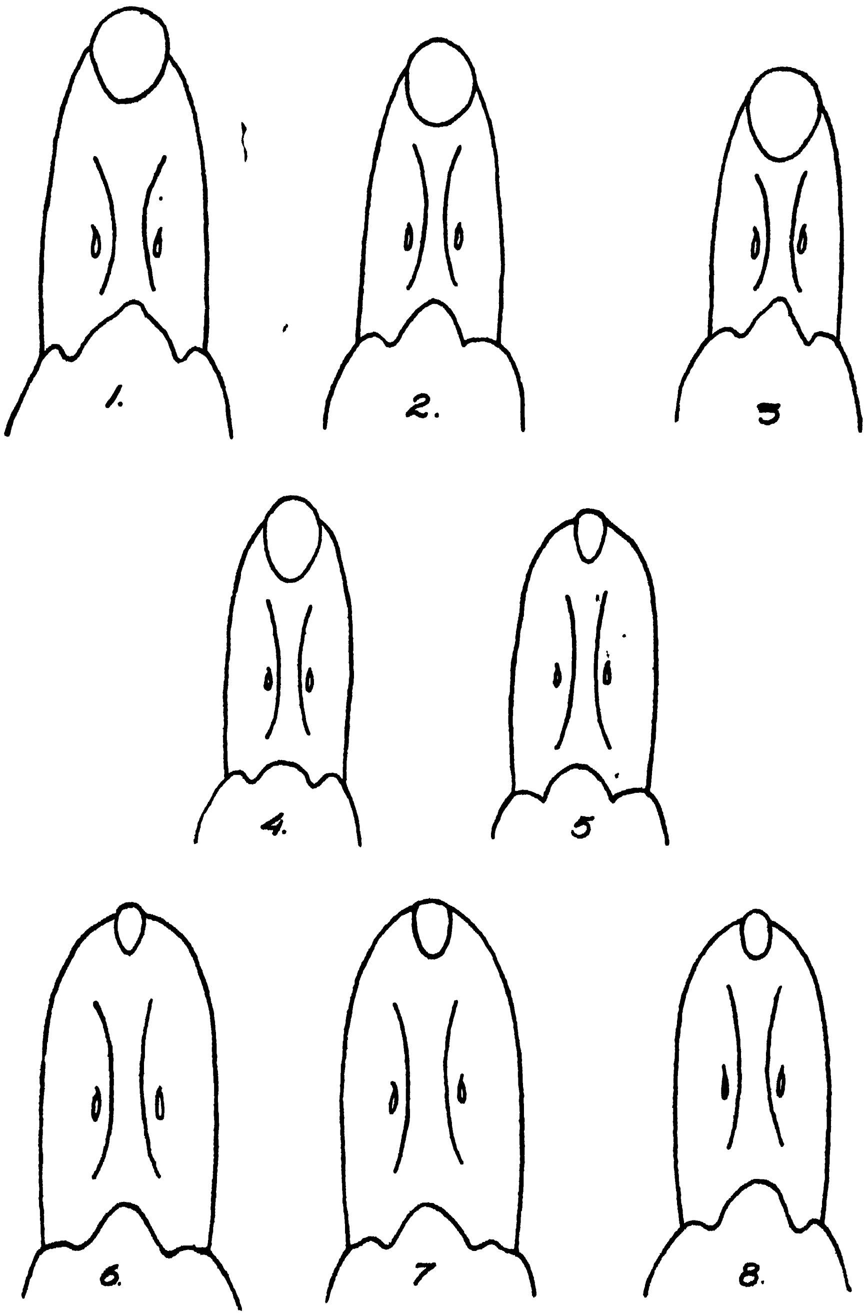


FIG. 1. Bill outlines, Barrow's Golden-eye, American Golden-eye.

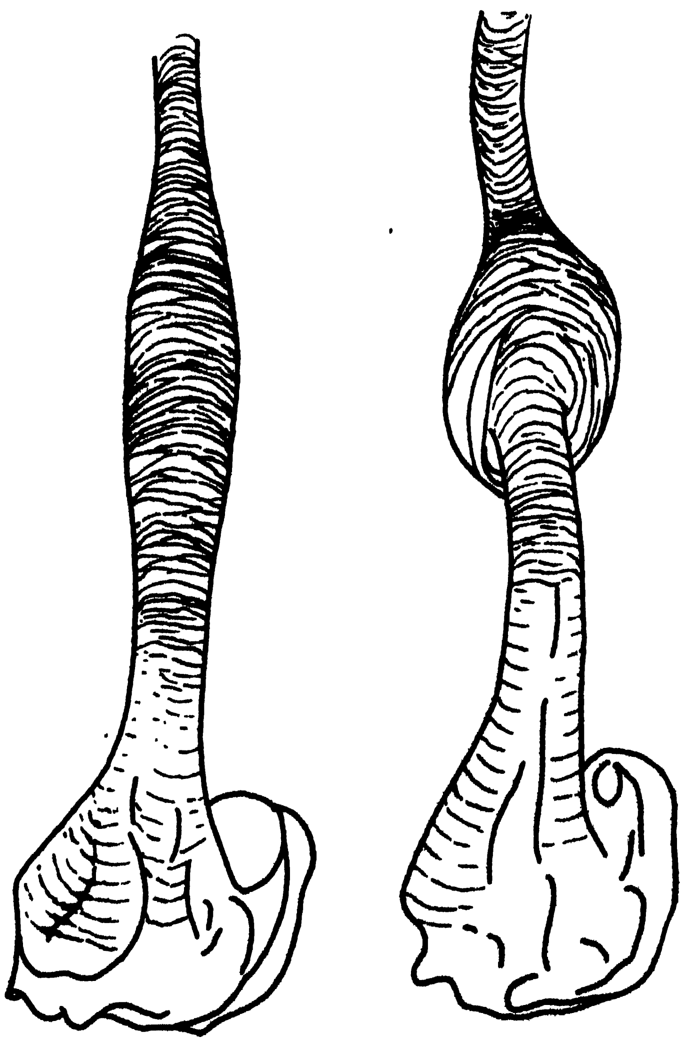


FIG. 2. Trachea adult ♂ Barrow's Golden-eye (top), adult ♂ American Golden-eye (bottom). Natural size.

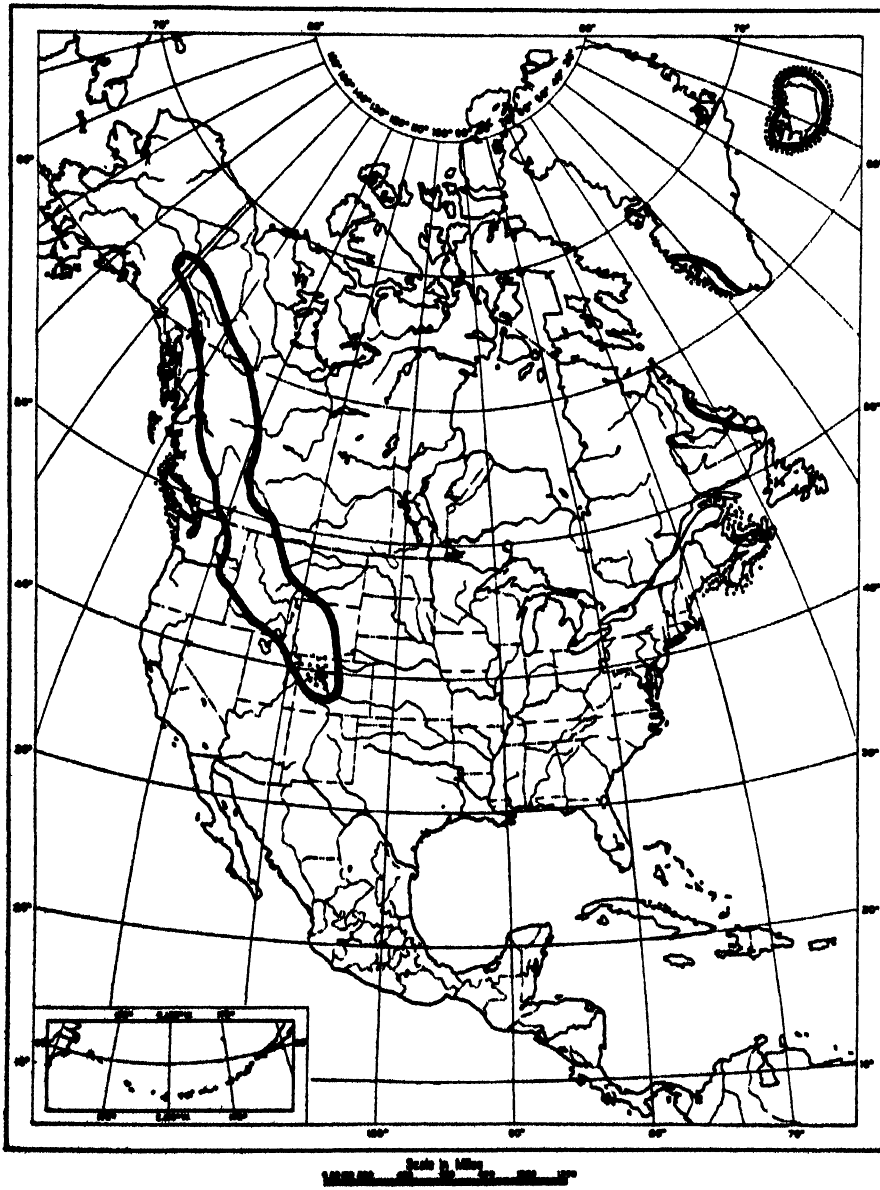


FIG. 8. Distribution of Barrow's Golden-eye. Principal breeding range outlined; principal known wintering range dotted.

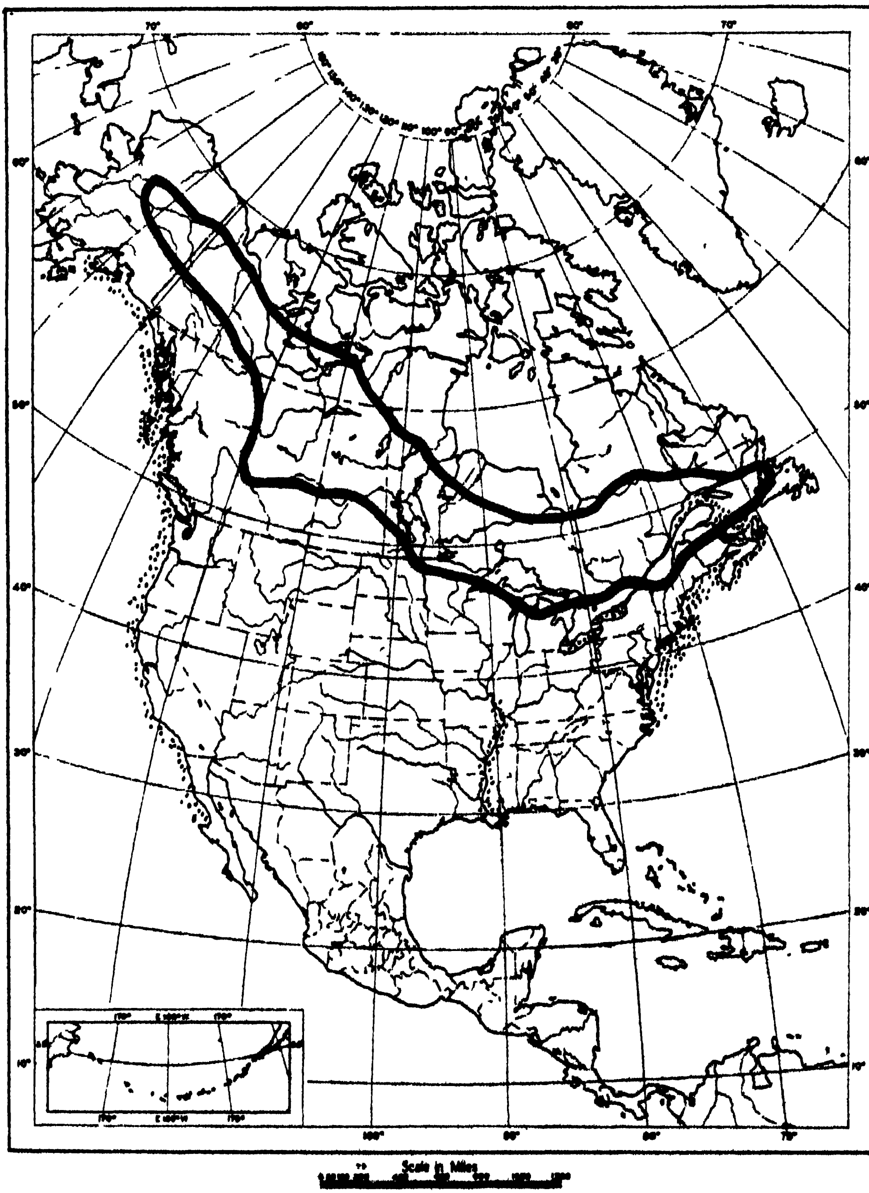
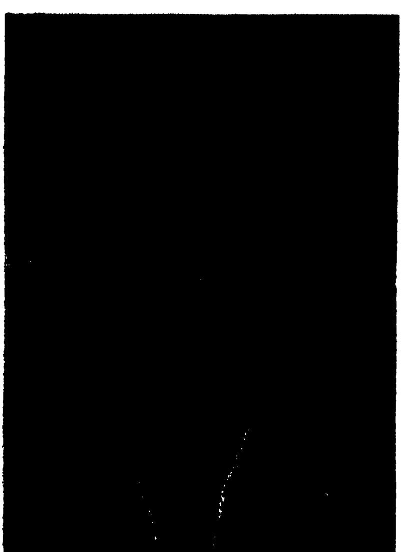


FIG. 4. Distribution of American Golden-eye. Principal breeding range outlined: principal wintering range dotted.

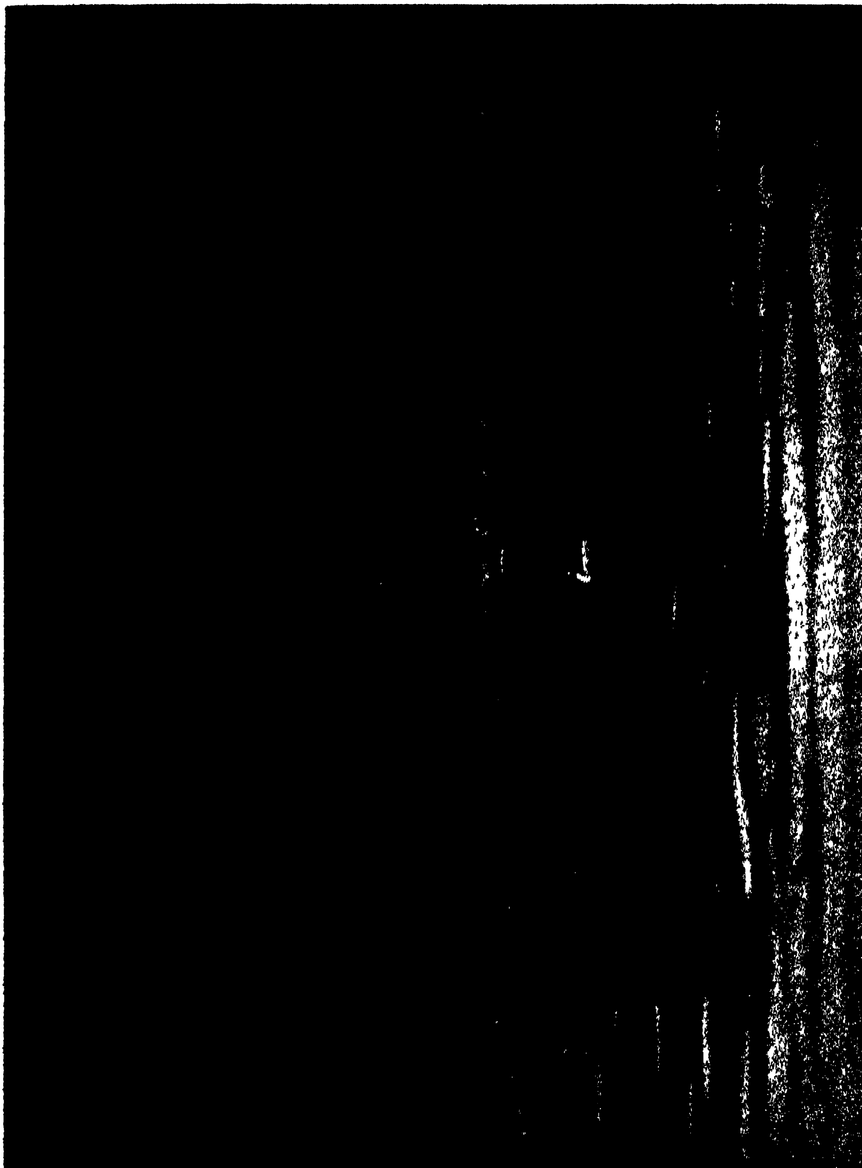
BARROW'S GOLDEN-EYE ADULT ♂ (LOWER) AMERICAN GOLDEN-EYE ADULT ♂ (UPPER)

DORSAL VIEW ♀ BARROW'S GOLDEN-EYE SHOWING EXTENT OF SUMMER FADING, LEFT TO RIGHT— ♀ ADULT (MAY 11), ♀ YEARLING (JUNE 17), ♀ YEARLING (AUGUST 17)



NESTING SITE BARROW'S GOLDEN-EYE, CUMMINGS LAKE, B C

♀ BARROW'S GOLDEN-EYE WITH 13 DOWNY YOUNG, LEW LAKE, B C.



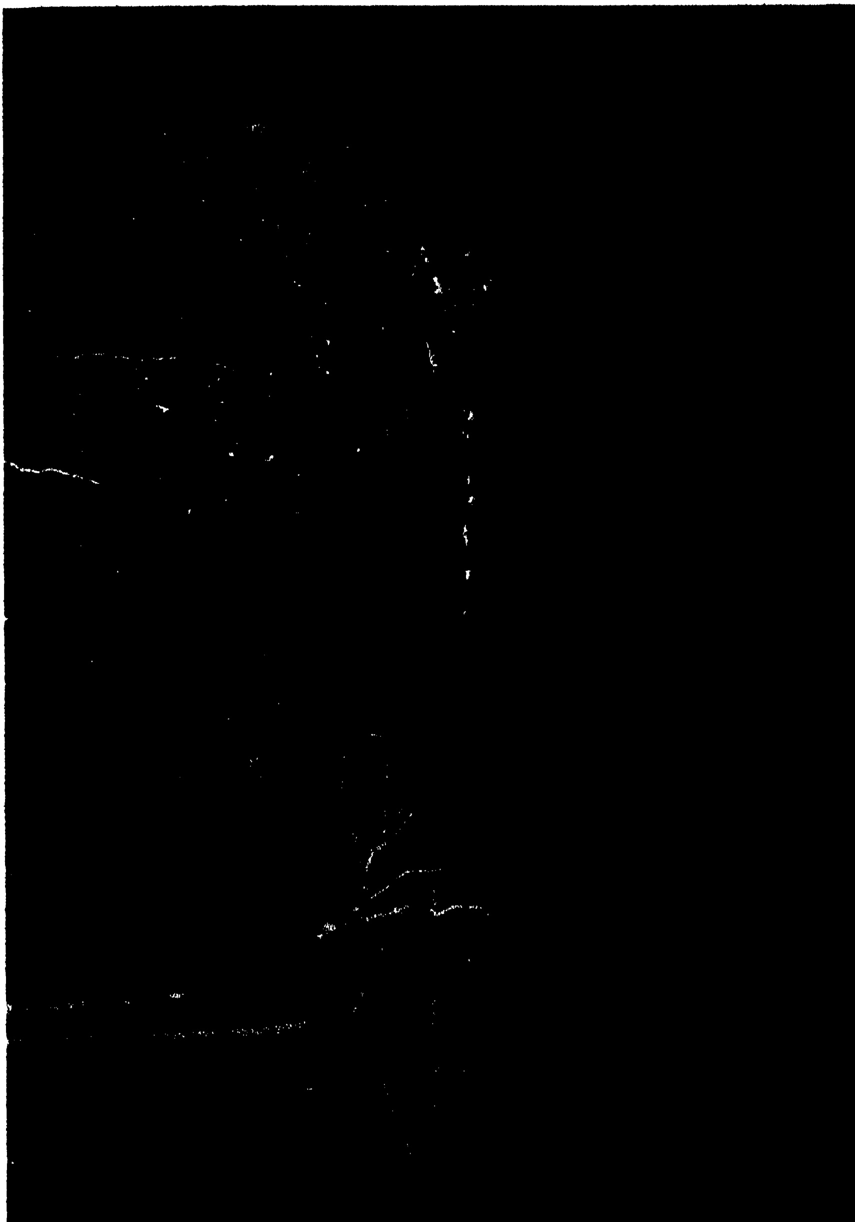
ADULT ♂ BARROW'S GOLDEN-EYE AWAITING ♀ ON TERRITORY

♀ BARROW'S GOLDEN-EYE AND BROOD
149 MILE LAKE, B.C.

♀ BARROW'S GOLDEN-EYE AND BROOD
SEEKING COVER, HORSE LAKE, B.C.

HORSE LAKE, B.C.

♀ BARROW'S GOLDEN-EYE AND BROOD,
HORSE LAKE, B.C.



BROOD BARROW'S GOLDEN-EYE ON FEEDING GROUND UNDER OVERHANGING BRUSH, HORSE LAKE, B.C.

THE ORDOVICIAN SECTION AT COBOCONK, ONTARIO

By Vladimir J. Okulitch
Department of Geology, University of Toronto

Abstract

A description of formations of Black River (Ordovician) age near Coboconk, Ontario, is presented. Four formations, to which the following local names are given, are described.

Shadow Lake—18 feet of shaly and magnesian limestone.
Gull River—50 feet of light grey aphanitic limestone.
Moore Hill—12 feet of dark grey fossiliferous limestone. (Tetradium beds.)
Coboconk—20 feet of massive limestone with abundant *Columnaria halli.*
Total thickness—100 feet.

Faunal lists for each of the formations are supplied. It is concluded on the basis of both the fauna and the lithology that, in all probability, Shadow Lake and Gull River formations can be correlated with the Pamelia; Moore Hill, with the Lowville; and Coboconk with the Chaumont formations, as exposed near Kingston, Ontario.

Introduction

During the fall of 1938 I made a detailed study of the rock outcrops at, and in the immediate vicinity of, Coboconk, Ontario. The strata exposed are of Middle Ordovician age, and belong to the Black River Group.

I am much indebted to Dr. Jack Satterly of the University of Toronto, and Mr. H. S. Armstrong, a graduate student in the Department of Geology, for their very kind assistance in measuring the section and in the collection of fossils. I am also very grateful to Dr. M. Fritz, for her identification of some of the Bryozoa collected in the area; and to Miss M. Turner for similar work with the Ostracoda.

Previous work in the area was done by Mr. Alexander Murray (1852, 1853). The results of his work are incorporated in the Geology of Canada, 1863. From 1908 to 1911 Dr. W. A. Johnston, also of the Geological Survey, mapped the area and described the results of his work in Summary Reports published in 1910, 1911 and 1912. During 1911 Professor Percy E. Raymond collected and identified some fossils from this general locality. This work was done mostly west of Coboconk, in the vicinity of Lake Simcoe. These workers have determined the general geographical distribution of the various formations and recognised the presence of Lowville and Leray formations of the Black River Group, overlain by the Trenton. They also very accurately described the lithology and the fauna of the various subdivisions. In the 30 years that passed since, however, new road cuts and new quarries have exposed

better and more continuous sections, and our ideas of the Black River and Trenton formations have undergone a considerable change. It therefore seems desirable to give a detailed description of the excellent sections near Coboconk, with the view to extend these studies both east and west in the coming field seasons. It will be especially interesting to extend the study of these formations east towards Kingston, in order to correlate the Lake Simcoe and Coboconk formations with the better known eastern sections. This is especially so since Dr. G. Marshall Kay has done very considerable work on the Middle Ordovician near Napanee and Kingston and has expressed the opinion (1937, p. 256) that Coboconk limestone, previously referred to as Leray, is in reality Lower Trenton.

GENERAL GEOLOGY

The Black River formations form a narrow belt extending almost due east-west from Kingston to Victoria Harbour on Georgian Bay. To the south of the Black River belt is a much wider belt of Trenton limestones, in turn overlain by the Utica and the Lorraine. North of this Palaeozoic area is the Canadian Precambrian shield, represented in this region by the Grenville crystalline limestones and the Laurentian gneisses and granites. The Palaeozoic strata dip gently southward, the amount of dip varying between 15 and 25 feet per mile.

The surface of the underlying Precambrian rocks is very irregular; this irregularity is reflected in the variable thickness of the lowest Palaeozoic members, and occasional "islands" of Precambrian rocks within the Palaeozoic belt. One of the most prominent of such "islands" or monadnocks is a hill about a quarter of a mile west of Rohallion at the northernmost extremity of Canal lake.

There is a considerable variation in thickness and lithological characteristics of the Black River strata exposed in the area. This variability prevents extensive correlations and generalizations at this time. Much detailed work over a much wider area is necessary before such generalizations will become possible. In order to avoid possible confusion in the future, local names are suggested for the exposed formations. That this is the more cautious procedure is further indicated by the uncertain status of the Black River formations in Canada at present. In this paper I shall confine myself to description of the Black River outcrops on highway number 35 between Coboconk and Norland. Since the strata dip southward, we see them in their natural ascending order if we approach Coboconk from the north.

Coming from Norland the highway follows for some time the low ground near Mud Turtle lake (popularly known as Shadow lake). The

only outcrops visible are those of the Precambrian age. At the southern extremity of the lake the road climbs a 50 to 60 foot escarpment. The escarpment is made of the lowest Palaeozoic rocks resting unconformably on the deeply eroded Precambrian surface. From here on, to beyond Coboconk, successively higher beds are exposed along the highway, with some unavoidable repetition of strata due to unevenness of the present surface. The outcrops are separated one from another, and so can be most conveniently described in a systematic order going from north to south.

SHADOW LAKE QUARRY AND ROAD CUT

On the flat surface just below the Palaeozoic escarpment are scattered Precambrian outcrops. Immediately south of the last undoubted Precambrian outcrop the surface begins to rise gently towards the escarpment proper. On this sloping surface lie large blocks and boulders of Ordovician limestone and Precambrian gneiss and granite. The Precambrian rocks predominate, so it seems reasonable to suppose that the actual Precambrian surface is a few (3 to 5) feet higher than the level of the last undoubted outcrop.

Seven feet above the level of the Precambrian outcrops is the first exposure of the Ordovician rocks. Since, as stated in the preceding paragraph, the level of the Precambrian surface is probably higher than the level of the outcrops, the actual gap in the section is probably not more than 5 feet, and possibly only about 3 or 4 feet.

The accompanying table (1) gives the details of the section exposed in the road cut and in the small quarry just west of the road. The lower part of the section is shown more completely in the road cut, but the upper portion, especially the light grey aphanitic limestone, can be seen to better advantage in the quarry. The section starts with seven feet of purple and greenish shale and argillaceous limestone and magnesian limestone. This is overlain by eleven feet of more compact and more distinctly bedded soft greenish shale and dolomitic limestone, with some beds of aphanitic magnesian limestone or dolomite. Some of the beds show mud cracks. The entire 18 feet thus exposed naturally fall into a unit. It is suggested that the name *Shadow Lake formation* be used for this series of beds. The uppermost seven feet of this series is exposed in the quarry, making up the floor and some six feet of the quarry wall. (See photograph, fig. 2.)

Overlying the Shadow lake beds are nine and a half to ten feet of thick- and thin-bedded, dove grey, aphanitic limestone with some fossils and numerous stylolitic partings. The appearance of these beds is wholly unlike the Shadow lake formation and it is considered to be a distinct

FIG. 1. Shadow Lake formation. Exposure on highway between Norland and Coboconk, just above Precambrian surface.

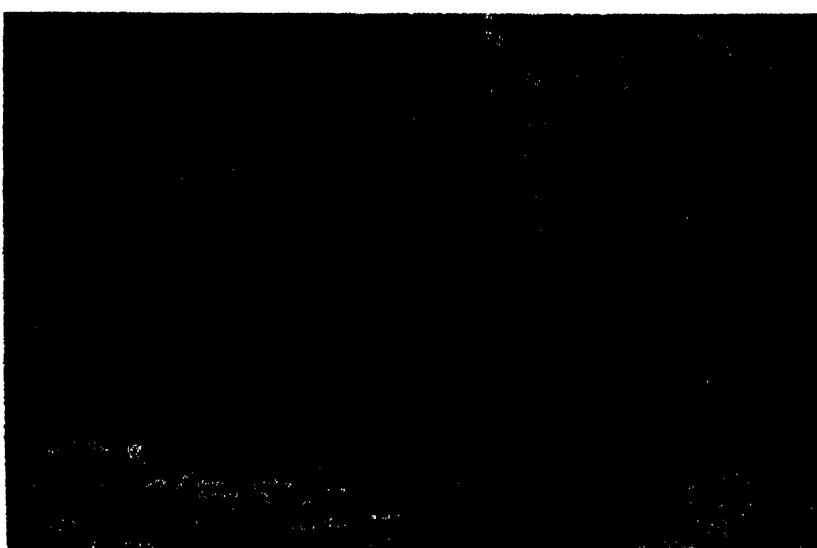


FIG. 2. Upper portion of Shadow Lake and the bottom of Gull River formations. Quarry off Norland—Coboconk highway.

formation. The name *Gull River formation* is proposed for these beds, as they are well exposed farther along the road not far from Gull river, connecting the Mud Turtle lakes with Balsam lake. The total thickness of Gull River formation is probably about 45 feet, and only the lower part of it is exposed at this locality. The best exposures of the lower 10 feet are in the small quarry west of the road.

Detailed description of beds exposed at this locality follows:

TABLE I

SECTION NEAR SHADOW LAKE, HIGHWAY No. 35, AND SMALL QUARRY WEST OF ROAD

Description

Top of section

Bed Nos.		Thickness
19	Light brownish grey, aphanitic limestone. Somewhat fractured. Contains some very fine intraformational conglomerate. Not fossiliferous..	4'- 9"
18	Light brownish grey, aphanitic limestone, light grey to buff on weathering. The rock is honeycombed with numerous tubes or cavities filled with brownish shaly material. On weathering the shale is in many cases washed out, leaving the rock with numerous irregular depressions. General appearance of "birdseye limestone"........ *Rafinesquina minnesotensis*, *R. clara*, *Strophomena* sp. *Lophospira perangulata*. *Hormotoma* sp., Bryozoa.	1'- 4"
17	Brownish grey limestone weathering to light dove grey. Contains numerous calcite-filled tubes and stylolitic partings. Few fossils.. *Rafinesquina cf. alternata*, *Bathyurus extans*, *Leperditia canadensis*.	8"
16	Similar to bed 17, some greenish shaly layers...................	1'- 4"
15	Mottled, greenish grey, aphanitic limestone.....................	6"
14	Aphanitic, dove grey limestone, brown on non-weathered surfaces.	6"
13	Brownish, but dove grey on weathering, aphanitic limestone...... *Tetradium cellulosum*, *Lophospira cf. bicincta*, trilobite fragments, *Isochilina cf. ottawa*.	10"
12	Brownish grey to dove grey aphanitic limestone, light grey on weathering. Stylolitic partings, crystals of pyrite. Numerous poorly preserved fossils.. *Rafinesquina cf. alternata*, *Isotelus gigas*, ostracod fragments.	9"
11	Bluish grey or dove grey aphanitic limestone..................	1½"
10	Shaly parting. Greenish to buff shale. Ostracods, bryozoa......	2"
9	Brownish grey, aphanitic limestone; dove grey to buff on weathering; greenish shaly layer on top. Calcite stringers or tubes filled with calcite.. *Lophospira perangulata*, *Isochilina cf. ottawa*, *Leperditia canadensis*.	1'- 4"
8	Aphanitic, dove-grey limestone breaking irregularly into thinner beds. Buff to greenish on weathering. Stylolitic parting.......	13"

TABLE I—*Cont.*

Bed Nos.	Top of Section	Thickness
7	Dove grey, aphanitic limestone in a single bed. Fragments of small fossils	5″
6	Dense, dove-grey limestone, lithologically resembling beds above..	5″
	Bottom of Gull River formation.	
	Top of Shadow Lake formation	
5	Thin bedded (1 to 2 inch), greenish shaly limestone or dolomite. Very soft and crumbly. No fossils....	1′-10″
4	Fine grained to aphanitic, greenish to buff, magnesian limestone; hard; with conchoidal fracture; mottled with reddish patches. No fossils....	2′- 9″
3	Brownish to green, somewhat mottled magnesian limestone or dolomite. Medium grained. Interbedded with greenish shale. Not fossiliferous.... Bottom of section in the quarry, lower beds exposed on the side of the road.	2′- 4″
2	Soft greenish shale and argillaceous magnesian limestone or dolomite	4′- 0″
1	Purple and green, mottled shale and argillaceous limestone or dolomite....	7′ -0″
	Total about....	28′- 0″
	Base of section.	
	Gap of about 5 feet.	
	Precambrian Surface.	

Dr. W. A. Johnston (1912, p. 254), summarising the results of his work in the Lake Simcoe and Kirkfield area, thus describes the lowest (basal) beds in that district.

"*Black River* (*group*)—

1. Basal series of sandstones, shales, etc.

"Resting unconformably on the Precambrian crystalline rocks in the Simcoe district, Ontario, as a basal series consisting of coarse calcareous sandstone or arkose passing upward into red and green shales with intercalated lenses or thin beds of sandstone, and occasionally thin beds of fine-grained limestone. The thickness of this series varies and the beds are frequently absent on the sides and tops of ridges or domes of the crystalline rocks, where the limestones are seen to rest directly on the old floor. The sandstone and shales are best developed in basins between ridges of the crystalline rocks where they occasionally have a maximum

thickness of about 40 feet. They are local in character and derivation, and evidently represent the old soil covering of the Precambrian rocks somewhat sorted, rearranged, and recemented, and it seems probable that they represent the initial near-shore deposit of the next succeeding formation."

It is obvious from this description that the "Basal Series" of Johnston is equivalent to the Shadow Lake formation. Since these beds occupy an extensive area, and are sufficiently distinctive to be readily recognized and distinguished from other beds, it is considered a proper step to give them a distinctive name.

The relative position of the Shadow Lake formation, below the more fossiliferous beds of the Black River group, suggests that it might be equivalent to Pamelia. The complete absence of fossils, however, makes a convincing correlation impossible. Beds overlying the Shadow Lake formation, and for which the name Gull River formation is suggested, are both faunally and lithologically of the Black River type Ulrich, Raymond and Johnston (1910, 1911, 1912) thought that these beds were probably equivalent to the Lower Lowville. The work of Cushing (New York State Museum, Bull. 145, 68-79, 1910). A. E. Wilson (1932) and Kindle (1916) suggests, however, that these beds are more probably equivalent to the Pamelia, as exposed in the state of New York, near Ottawa, Ontario, and near Kingston, Ontario.

GULL RIVER FORMATION

Seven-tenths of a mile farther south, or 2.2 miles north of Coboconk, the highway skirts the east side of another escarpment or cliff, about 45 feet high. This escarpment is made almost entirely of light grey compact limestone and magnesian limestone, practically without fossils. The level of the road at this point, as determined by a hand level and checked by a surveying aneroid, is 12 feet below the level of the upper bed at Shadow Lake section. However, assuming the average dip to be 20 feet per mile, we should have gained, in the 0.7 miles, 14 feet in the stratigraphic section, and therefore the lowest beds here should be just above the highest bed at Shadow Lake section. This reasoning is confirmed by lithology. The lowest bed is different from any seen at our first locality, while at the same time undoubtedly belonging to the same group of beds which we called the Gull River formation.

The base of the section is made up of thin- and thick-bedded, light-coloured aphanitic limestone or magnesian limestone, interbedded with some buff and greenish shaly limestone. These lowest beds contain a few *Zygospira recurvirostris*. Higher up the beds become very compact,

aphanitic, light grey limestone. There are some stylolitic partings and some of the upper layers have a mottled appearance. They greatly resemble the lowest beds exposed at the village of Coboconk. One or two beds contain numerous calcite-filled tubes. *Leperditia fabulites* and *L. cf. canadensis* seem to be the only fairly common fossils in these middle layers. Two feet below the uppermost layer is a bed with scattered *Tetradium cellulosum* and *T. syringoporoides*. This layer is aphanitic in texture, and is a brownish, grey-weathering limestone, with pink mottling. It also contains *Leperditia canadensis*, *Liospira* sp., *Lambeophyllum cf. profundum*, fine-meshed Bryozoa, and crinoid stems. It is considered that these fossiliferous beds belong to the succeeding Moore Hill (Lowville) formation.

The beds exposed at the "roadside" escarpment with the upper 9.5 feet of beds in the quarry at Shadow lake naturally fall into a unit. Their total thickness cannot be exactly determined without a more comprehensive survey of the area. I believe that the upper 4 feet or so belong to the Moore Hill formation. If this is correct, then the section exposed is 45 feet minus 4 feet, or 41 feet, plus the 9.5 feet at Shadow lake, or a total of some 50 feet. This is probably the maximum possible thickness, and is correct only if our assumption is true that the lowest beds at the "roadside" section immediately follow the uppermost bed at the Shadow Lake section. Should the dip be less than 20 feet per mile, and the two sections overlap, then the thickness of the Gull River formation might be reduced to about 35 or 40 feet as the possible minimum.

Johnston (1912, p. 254) in describing beds immediately overlying the "basal beds" in the Brechin and Kirkfield areas, states that:—"2. Lower Lowville (Beatricea beds): The red and green shales pass upward into impure magnesian limestones which on fresh fracture are greenish-grey in colour and weather yellowish brown. They are characterized by numbers of drusy cavities, occasional quartz grains and crystals of pyrite or limonite, and are generally barren of fossils. They are only a few feet in thickness, and are followed by 6 to 10 feet of fossiliferous blue-grey to dove-coloured limestone characterized by an abundance of a species of Beatricea. These beds somewhat resemble in physical character the typical fine-grained "Birdseye" limestone, but are less compact in texture, and weather to a shaly mass. They are overlain by from 7 to 10 feet of unfossiliferous magnesian limestone very similar to the beds which immediately underlie them. A small collection of fossils from the Beatricea beds, as exposed on the west side of Lake Couchiching, Ont., was obtained last year, and the fossils were determined by Mr. E. O. Ulrich of the United States Geological Survey as belonging to the lower middle Lowville. One of the best localities in the district where these beds are ex-

posed is about 2 miles south of Dartmoor post-office on lots 16 and 17, concession I, of Dalton township, and on lot 25, concession VI, of Carden township. A larger collection of fossils was made at this locality the past summer and they have been determined by Mr. P. E. Raymond of this Survey."

In 1911 Dr. Johnston, giving the generalized section in the Simcoe district of Ontario (Johnston, 1911, p. 190), describes the same sequence of beds. His subdivisions 3, 4 and possibly 5, apparently are equivalent to the "Beatricea beds". The maximum thickness given is 28 feet.

It is my belief that the "Beatricea beds" are equivalent to the Gull River formation as established in the vicinity of Coboconk. The thickness of the formation apparently varies from about 20 to 50 feet, in the region between Lake Simcoe and Balsam lake. This great variability will probably preclude very precise correlations within the formation over any great area. At Coboconk the main characteristics of the formation are its fine grain, much of the material being aphanitic or "lithographic" in texture, and the relative scarcity of fossils. Farther west the formation apparently becomes somewhat thinner and at the same time more fossiliferous. Combining the faunal lists as supplied by Dr. Johnston and the results of my own collecting, we get the following assemblage of fossils:

GULL RIVER FORMATION

FAUNAL LIST

Beatricea cf. gracilis Ulrich.
B. sp. ind.
Tetradium halysitoides Raymond.
T. cellulosum (Hall).
Cyclocystoides halli Billings.
Rafinesquina minnesotensis Winchell.
R. clara Okulitch.
R. cf. alternata (Emmons).
Strophomena incurvata (Shepard).
S. sp.
Zygospira recurvirostris Hall.
Ctenodonta nasuta (Hall).
Cyrtodonta cf. huronensis Billings.
C. subtruncata (Hall).
C. sillimanensis ? Ulrich.
Vanuxemia rotundata (Hall).
Pterotheca attenuata (Hall).

Helicotoma sp.
Liospira progne (Billings).
L. vitruvia (Billings).
Eotomaria vicina Ulrich and Scofield.
Clathrospira subconica (Hall).
Lophospira concinnula Ulrich and Scofield.
L. bicincta (Hall).
L. perangulata (Hall).
Raphistomina lapicida Salter.
Holopea cf. concinnula, Ulrich and Scofield.
Subulites sp.
Hormotoma sp.
Cameroceras sp.
Orthoceras cf. recticameratum Hall.
O. amplicameratum Hall.
O. multicameratum Emmons.
Loxoceras allumettense (Billings).
Isotelus gigas, Dekay.
Onchometopus simplex Raymond and Narroway.
Bumastus indeterminatus (Walcott).
Bathyurus johnstoni Raymond.
B. cf. extans Hall.
Pterygometopus callicephalus (Hall).
Leperditia fabulites Conrad.
L. cf. canadensis.
L. amygdalina Jones.
Isochilina armata Walcott.
I. sp.

Raymond (Johnston, 1912, p. 255) has already noted that this fauna is "peculiar in many ways". To quote him—"The facies is distinctly Lowville, although *Orthoceras multicameratum* is the only typical Lowville fossil present. *Cyclocystoides* and *Bumastus indeterminatus* have not previously been found below the Leray-Black River, while *Onchometopus simplex*, *Bathyurus johnstoni*, the small form of *Strophomena incurvata*, and several ostracods not enumerated above, occur at exactly this same horizon, just below the typical Lowville, near Clayton, New York, and at Ottawa".

With the present somewhat extended faunal list, it is clear that the facies is Black River, of lowest Lowville, or more probably Pamelia type. The presence of *Tetradium cellulosum*, *Rafinesquina clara*, and *R. minnesotensis*, would suggest Lowville, while *Beatricea gracilis*, *Bathyurus john-*

stoni, and the ostracods, particularly *Leperditis amygdalina* Jones strongly suggest Pamelia. Personally I am inclined to consider Gull River equivalent to the Pamelia. Because of its peculiarities and the lithology distinct from the overlying and underlying formations, I believe it will be of advantage to give this series of beds a distinctive name. Gull River seems to be an appropriate term, as it is in the vicinity of this river that the strata reach their maximum thickness, and have the distinctive "lithographic" texture.

MOORE HILL FORMATION

(LOWVILLE)

Along the road, 1.3 mile farther south or 0.9 mile north of Coboconk, is an outcrop of medium-grained dark grey limestone. This outcrop is partly exposed in the ditch along the road, and partly is seen as a low ledge behind a farmhouse, running in a general westerly direction. The limestone is typically Lowville with abundant *Tetradium cellulosum*. A much better section of the same strata is exposed at the village of Coboconk. For this reason only a brief description will be given here.

The lowest beds are aphanitic, buff to light grey limestone, with conchoidal fracture. The rock is filled with "birdseyes" and calcite-filled tubes. It is interbedded with some thin, greenish, possibly magnesian layers. Four feet higher up are several prominent stylolotic partings, and the rock becomes mottled, with pink patches. The aphanitic material continues to about seven feet above the lowest bed. These lower beds appear to be equivalent to the upper layers of the Gull River formation. Seven feet above the base of the section the character of the rock changes abruptly to bluish fine-grained to aphanitic limestone with numerous fossils. The most prominent fossils are *Tetradium syringoporoides*, *Orthoceras multicameratum*, *Rafinesquina cf. alternata*, *Pachydictya* sp. ind., *Helicotoma planulata*, *Leperditia fabulites*. At 8.5 feet, appear numerous large heads of *Tetradium fibratum*, and fragments of asaphid trilobites. These beds can, with justification, be called *Tetradium* beds. Up to 12 feet the bluish fine-grained limestone continues to be very fossiliferous, some layers in particular being apparently filled with twisting tubes made of crystalline calcite. They apparently represent worm tubes. At 12 feet, *Tetradium cellulosum* and *Stromatocerium rugosum* are quite numerous. Above this horizon the rock gradually is becoming coarser grained, and at the top, 18 feet above the base of the outcrop, the most common fossils are *Lambeophyllum profundum* and crinoid stems.

The total section exposed is about 20 feet thick and, as seen from the foregoing description, it starts in the light grey to buff aphanitic beds of the Gull River formation, and extends into the fossiliferous typical Low-

ville (Moore Hill), characterized by abundance of *Tetradium cellulosum*. The term Moore Hill formation is suggested for local use, as this series of beds is quite distinct both faunally and lithologically from the aphanitic Gull River formation below, and the Coboconk (Leray) formation above. I am hesitating, at this time, to apply the term Lowville for this series of beds, because the Gull River formation, as stated before, also has a Lowville aspect; using the term Lowville for Moore Hill beds alone, might imply, therefore, a restricted usage for the very useful term Lowville.

MOORE HILL FORMATION

FAUNAL LIST

Stromatocerium rugosum Hall.
Lambeophyllum profundum (Conrad).
Tetradium cellulosum (Hall).
T. fibratum Safford.
T. halysitoides Raymond.
T. cf. syringoporoides Ulrich.
T. clarki Okulitch.
Rhynidictya sp.
Rafinesquina minnesotensis Winchell
R. cf. alternata (Emmons).
R. clara Okulitch.
R. n. sp.
Strophomena filitexta Hall.
Zygospira recurvirostris Hall.
Ctenodonta cf. gibberula Salter.
Trochonema sp.
Hormotoma angustata (Hall).
H. gracilis (Hall).
Helicotoma planulata Salter.
Liospira sp.
Orthoceras cf. multicameratum Emmons.
O. cf. recticameratum Hall.
Cycloceras sp.
Bathyurus extans Hall.
B. spiniger (Hall).
Isotelus gigas Dekay.
Bumastus sp.
Pterygometopus callicephalus (Hall).
Leperditia fabulites Conrad.
Isochilina armata Walcott.

This list indicates that Moore Hill formation is of Lowville age. It also shows a close relationship with the fauna of Gull River formation. The upper limit of Moore Hill formation is determined by the range of *Tetradium cellulosum*.

The Moore Hill beds are undoubtedly equivalent to division 3 (Upper Lowville) of Johnston (p. 255, 1912). To quote:--"The Beatricea beds are overlain by about 20 feet of fine-grained even-bedded dove-coloured limestone characterized by *Bathyurus extans* and in the upper portion of a great abundance of *Tetradium cellulosum*. At the top are a few feet of coarser-grained dark coloured limestone, and in the section exposed in the quarry at Coboconk, Ont., Mr. Raymond considers that the line between the Lowville formation and the next succeeding formation, which was named the Coboconk formation and correlated with the Leray formation of the New York State geologists, in last year's Summary Report, should be drawn about 9 feet above the fine-grained beds, as the *Tetradium cellulosum* still appears in these beds."

SECTION AT COBOCONK, ONTARIO

Exposed along the eastern bank of the river at Coboconk, and along the cliff marking the southern outskirts of the village are numerous exposures of Black River limestone. The best sections are along the new road cut on highway No. 35, and in the quarries of the Canada Lime Company Ltd. and the Toronto Brick Company Ltd. About 40 feet of beds is exposed. The lower part of the section is best seen along the road cut, while the uppermost beds are exposed in and back of the Canada Lime Company quarry. Mr. M. F. Goudge of the Dominion Bureau of Mines in his recent reports on Limestones of Canada (1935), gives descriptions and analyses of these rocks. A detailed stratigraphic description of the formations follows:

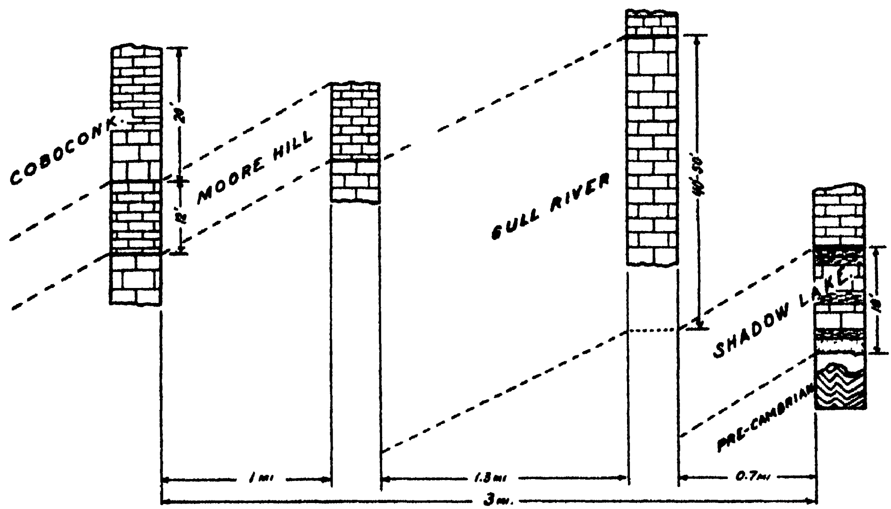
ROAD CUT, HIGHWAY NO. 35, SOUTH OUTSKIRTS OF THE VILLAGE OF COBOCONK

Bed No. — *From Base of Section*

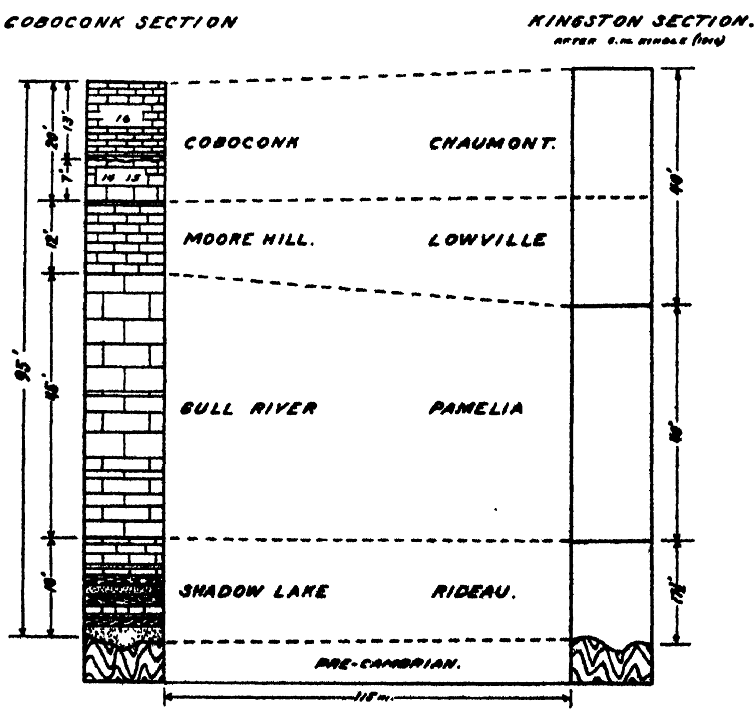
1. 17″—Aphanitic, light dove grey, weathering to whitish grey; limestone. Not fossiliferous.
2. 14″—Similar to 1, buff-weathering limestone with stylolitic partings and some pyrite.
3. 29″—Very light grey, weathering to buff grey limestone. Upper surface pitted, contains siliceous stringers, which might be worm burrows, some very fine brecciation.. General appearance of "birdseye" limestone. A few extremely small crinoid stems less than 1 mm. in diameter. Not fossiliferous.

ORDOVICIAN SECTION AT COBOCONK, ONT.

VERTICAL SCALE EXAGGERATED 170 TIMES
AVERAGE DIP 20 FT. PER MILE.



TENTATIVE CORRELATION.



Bed Nos. *From Base of Section*

4\. 10″—Light grey to brownish-grey limestone, mottled with reddish patches and containing paper thin partings of shaly material within the bed. Upper layer weathers greenish; cubes of pyrite. Not fossiliferous.

5\. 14″—Light grey, light grey to buff-weathering, aphanitic limestone. Upper layer green, contains some pyrite and is mottled with reddish patches. Calcite-filled tubes (birdseyes), numerous ostracods, *Leperditia amygdalina* Jones.

6\. 17″—Darker than the previous beds, aphanitic, mottled, buff-weathering limestone; stylolites on partings in the bed. Calcite-filled tubes. Large and small ostracods. *Leperditella inflata* ? Ulrich, *Leperditia canadensis* ?

Total 8′-7″.

Top of Gull River Formation.

Bottom of Moore Hill Formation.

7\. 21″
8\. 10″
9\. 43″
10\. 3″

77″—Form together a prominent heavy bed. Dark grey slightly brownish aphanitic limestone. Bed 10 is noticeably lighter in colour and makes a convenient key horizon. Beds 7 and 8 are not fossiliferous, while bed 9 contains abundant *Tetradium cellulosum*.
Tetradium cellulosum, *T. fibratum*, *T. halysitoides*, *T. cf. syringoporoides*, *Rhynidictya* sp., *Hormotoma gracilis*, *Isotelus cf. gigas*, *Leperditia fabulites* ?

11\. 13″—Fine grained, medium grey limestone, weathering to lighter grey. *Tetradium cellulosum* very abundant.
Tetradium cellulosum, *T. fibratum*, *T. cf. syringoporoides*. *Orthoceras cf. multicameratum*.

12\. 7″—Brownish to greenish grey, fractured and rubbly limestone. *T. cellulosum*, *T. fibratum*, Bryozoa, *Rafinesquina minnesotensis*, *R. cf. alternata*, *Rafinesquina* new species, *Zygospira recurvirostris*.

13\. 49″—A heavy massive bed; some fracturing. Dove grey, grey weathering aphanitic to fine grained limestone. Very few *Tetradium cellulosum*. *Tetradium cellulosum*, *T. clarki* ?, *Rafinesquina cf. alternata*, *R. clara*, *Zygospira recurvirostris*, *Isotelus gigas*, *Bumastus* sp., ostracods.

Total 12′-2″.

Top of Moore Hill Formation.

Bottom of Coboconk Formation.

14\. 43″—Medium grained to fine grained, grey to brownish grey limestone. Brown on weathering; irregularly fractured; and actually consisting of several irregular beds.

Stromatocerium rugosum, Columnaria halli, Lichenaria sp., *Lambeophyllum profundum, Fletcheria sinclairi,* Bryozoa, *Rafinesquina alternata, R. clara, Rhyncotrema increbescens, Doleroides* sp., *Zygospira recurvirostris, Lophospira perangulata, Liospira* sp., *Phragmolites compressus, Leperditia cf. fabulites.*

15. 60″—Composite bed consisting of four or five beds. Fine grained, grey to brownish grey limestone. Brown on weathering. Upper surface bluish grey, and somewhat nodular due to partial solution and weathering. Very numerous *Columnaria halli* and *Stromatocerium*, as in bed 14.
Stromatocerium rugosum, Stromatocerium cf. canadense, Columnaria halli, Fletcheria cf. sinclairi, Lambeophyllum profundum, Lichenaria carterensis, Lichenaria n. sp., *Rafinesquina* sp., *Nicholsonella laminata.*

Total 8′-7″.
Grand total 29′-2″.

Top of section.

While this is the top of the section in the highway cut, the section continues in the quarry of the Canada Lime Co. For convenience of comparison, the same bed numbers will be used in describing the quarry section, as were used for the road cut.

QUARRY OF THE CANADA LIME CO.

The quarry is located south of the village, and east of highway No. 35. The total thickness of beds exposed in the quarry is 30 feet. The quarry is bottomed on what we called bed 7, in the road cut, and below this is the aphanitic limestone of the Gull River formation. The aphanitic limestone is said by Goudge (1935) to be unsuitable for making lime. Only the most prominent fossils are mentioned in the descriptions.

Bed Nos. — Bottom of quarry.

7. 20″—Grey limestone. A few straight nautiloid cephalopods.
8.
9. 56″—Composite bed consisting of several 10 to 12-inch beds. Light grey aphanitic to fine grained limestone. Numerous *Tetradium cellulosum*. Typical Lowville limestone. Upper surface shaly, containing ostracods and fragments of trilobites. *Tetradium cellulosum, Pterygometopus callicephalus.*
10. 2″—Light grey aphanitic to fine-grained limestone.
11.
12. 19″—Massive, light grey, darker-weathering aphanitic limestone. Abundant Tetradium.
Tetradium cellulosum, T. fibratum.
13. 45″—Dove-grey, fine-grained limestone splitting into several 6″ to 12″ beds.
Tetradium cellulosum.

Top of Moore Hill Formation.

Bottom of Coboconk Formation.

14. 82″—Dove grey, medium to fine-grained limestone, weathering to
15. darker grey or brownish grey. Splitting into several thinner beds. The transition from 13 to 14 and 15 is not sharp and is established by observing the upper range of *Tetradium cellulosum*, which does not extend above 13. *Columnaria* and *Stromatocerium* are very abundant in 14 and 15.
The top of 15 looks like a top of a sedimentary series. The surface is very irregular and may represent a slight erosional unconformity. Above this contact the limestone is thin-bedded with coarser grain, the lower beds showing very well-developed cross-bedding.
Stromatocerium rugosum, *Columnaria halli*, *Lichenaria carterensis*, *Lambeophyllum profundum*, *Refinesquina alternata*, *R. clara*, *Liospira* sp.

16. 162″—Light grey, fine to medium-grained limestone. Beds 2 to 3 inches thick, in contrast to the heavy beds just below. The lower 20 inches show distinct cross-bedding. Some of the beds are oölitic.
Receptaculites occidentalis, *Stromatocerium rugosum*, *S. canadense*, *Lambeophyllum profundum*, *Calapoecia canadensis*, *Lichenaria* n. sp., *Graptodictya cf. proava*, *Phyllodictya varia*, *Hesperorthis tricenaria*, *Rafinesquina alternata*, *R. minnesotensis*, *R. clara*, *Strophomena filitexta*, *S. cf. corrugata*, *Leptaena cf. radialis*, *Zygospira recurvirostris*, *Rhyncotrema increbescens*, *Maclurites logani*, *Actinoceras bigsbyi*, *Isotelus gigas*, *Leperditia fabulites*.

Total thickness
31′-2″. Top of section.

Total thickness exposed at Coboconk is therefore 39 feet and 10 inches. Of these, 8 feet 5 inches belong to the Gull River formation, twelve feet to Moore Hill formation, and the remaining twenty feet to Coboconk formation. It is however questionable whether all of the twenty feet can be retained in the Coboconk and whether it will not be necessary to restrict this formation to beds 14 and 15.

COBOCONK FORMATION

Beds 14, 15, and 16

FAUNAL LIST

(Fossils occurring exclusively in bed 16 are marked by an *)

**Receptaculites occidentalis*
Stromatocerium rugosum

S. cf. canadense.
Beatricea cf. gracilis.
Columnaria halli.
**Calapoecia canadensis.*
Lambeophyllum profundum.
Lichenaria carterensis.
L. n. sp.
Fletcheria cf. sinclairi.
Graptodictya cf. proava (Eichwald).
Phyllodictya varia.
Nicholsonella laminata.
Rhyncotrema increbescens.
**Hesperorthis tricenaria.*
Rafinesquina alternata.
R. clara
R. minnesotensis
Strophomena filitexta.
S. cf. corrugata
Leptaena cf. radialis
Zygospira recurvirostris
Bellerophon charon
Holopea nereis
**Maclurites logani*
Hormotoma gracilis
Lophospira perangulata
Liospira sp.
Phragmolites compressus
Actinoceras bigsbyi
Hormoceras tenuifilum.
Isotelus gigas.
Leperditia fabulites.

This fauna is of distinctly Leray (Chaumont) type. Very similar faunas are associated with this formation in the State of New York, at Kingston, at Montreal and points east. The status of the Leray in Canada, however, has been put under a serious question by the work of Dr. G. Marshall Kay. According to Dr. Kay, what has been called Leray in Canada, at least in part, should be included with the lower Trenton, or more specifically, the Rockland formation. In his paper on the "Stratigraphy of the Trenton Group" (G. M. Kay, 1937, p. 256) Dr. Kay concludes that Coboconk limstone is equivalent to the Napanee member of the Rockland formation. He states that: "In Northumberland and

Peterborough counties, limestones lithologically similar to Coboconk, contain *Triplecia cuspidata* in the upper part, and overlie upper Black River, Chaumont limestones. The Coboconk formation contains *Maclurites logani*, *Receptaculites occidentalis*, *Hesperorthis tricenaria*, and *Calapoecia canadensis*,—forms characteristic elsewhere of the Rockland. The 'Dalmanella beds', originally called Rockland in this district, are thought to be lower Hull."

I disagree with Dr. Kay in this matter, at least in so far as the Coboconk limestone is concerned. According to Dr. Kay, the lower member of the Rockland formation—the Selby—is characterized by *Doleroides ottawanus* Wilson (G. M. Kay, 1937, pp. 252, 253) and also frequently contains *Calymene senaria* and *Dalmanella rogata*. Neither of these fossils is present in Coboconk. The Napanee member, at its type locality, contains an abundance of *Dalmanella rogata* and *Sowerbyella curdsvillensis*, and in its higher layers *Triplecia cuspidata* (Hall). As seen from the faunal lists, however, these Trenton forms are not present in the Coboconk.

In analysing the fauna of Coboconk formation, we see at once that all typical lower Trenton forms such as *Dalmanella rogata*, *Sowerbyella curdsvillensis*, *S. cericea*, *Platystrophia amoena*, *Camarella hemiplicata*, *Endoceras proteiforme*, *Calymene senaria*, etc., are lacking. On the other hand, the typical Black River fossils,—*Columnaria halli*, *Stromatocerium rugosum*, *Lambeophyllum* (*Streptelasma*) *profundum*, *Lichenaria carterensis*, *Rafinesquina minnesotensis*, *R. clara*, *Maclurites logani*, *Lophospira perangulata*, *Actinoceras bigsbyi*, *Hormoceras tenuifilum*, etc., are present. I am convinced, therefore, that Coboconk formation should be retained in the Black River Group.

It is obvious that the present unsettled condition of the Black River-Trenton boundary exists mostly because of lack of complete faunal lists from the type localities in the State of New York. Once such lists are available, it will be comparatively easy to decide the status of the Chaumont (Leray) and the Rockland formation in Ontario and Quebec. It is also obvious that there is no sudden break between the Black River and the Trenton faunas. Rather, we are witnessing continuous deposition during the Black River-Trenton epoch, and a correspondingly continuous change in the faunas. Under the circumstances, our subdivisions of this continuous record will necessarily have to be, to some extent, arbitrary and depend on a statistical evaluation of large fossil collections rather than on one or two "index" fossils. At present I am of the opinion that if the upper portion of the Leray in Canada contains a majority of Black River fossils and some Trenton forms as well, it would be better to con-

tinue regarding the whole of Leray as Black River and not assign its upper layers to the Rockland.

Coming back to Coboconk, however, should it be shown that part of the Leray in Canada is in reality Rockland, then only the upper part of the Coboconk formation, namely bed 16, could be transferred to the Trenton. This view is based on the fact that bed 16 contains *Calapoecia canadensis*, *Receptaculites occidentalis*, *Hesperorthis tricenaria* and *Maclurites logani*, i.e. forms which conceivably could be regarded as Rockland fossils. Beds 14 and 15 contain only the common Black River forms. Should this be done, the boundary between the Black River and the Trenton in the Coboconk district could very conveniently be placed at the top of bed 15.

CONCLUSIONS

Summarising the results of this investigation, we see that the Ordovician section at Coboconk is about 95 feet thick; this thickness distributed among four formations:

Coboconk	20 feet
Moore Hill	12 "
Gull River	45 "
Shadow Lake	18 "
Total	95 feet

It is probably too early at this stage of field work to attempt correlations with other areas. It is felt, however, that at least a tentative correlation, to serve as a working hypothesis until more information is obtained, will be useful. The nearest well-known section is at Kingston, Ontario, about 115 miles east of Coboconk. The Kingston section has been fully described by E. M. Kindle, in association with Dr. Alice E. Wilson and Kirtley F. Mather. Some modifications were later suggested by G. M. Kay.

Kindle's descriptions (1916, p. 40) seem to indicate that Shadow Lake formation closely resembles lithologically the Rideau formation, which is regarded to be the basal member of the Pamelia. Fine textured, aphanitic beds of Gull River formation, show some resemblance to the Pamelia proper, although in the absence of more extensive faunal lists a precise correlation is impossible. Kindle mentions, however, that the Pamelia at Kingston is "a fine-textured rock of dove-grey colour. It lies in even-bedded strata usually 6 inches to 2 feet in thickness, many of which have a texture approaching that of lithographic limestone. . . . In some of the

upper beds of the Pamelia, bands of stylolites are common." The thickness of the Pamelia in the Jackson's mill section is about 40 feet, which also agrees very closely with that of Gull River at Coboconk. Fossils found in the Pamelia at Kingston are closely related or identical with the ones found in the Gull River. Both formations also contain mud cracks.

Overlying the Pamelia at Kingston are the Lowville and the Leray (Chaumont), characterized respectively by *Tetradium cellulosum* and *Columnaria halli*. The combined thickness of Lowville and Leray is about 35 or 40 feet, which is only a few feet more than the combined thickness of Moore Hill and Coboconk formations.

We may conclude, I believe, that in a general way the Coboconk formations may be correlated with the Kingston formations as indicated above. A more precise correlation will have to wait until the rocks in the intervening area are surveyed and fossil collections made.

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THE FLAXVILLE PLAIN IN ALBERTA

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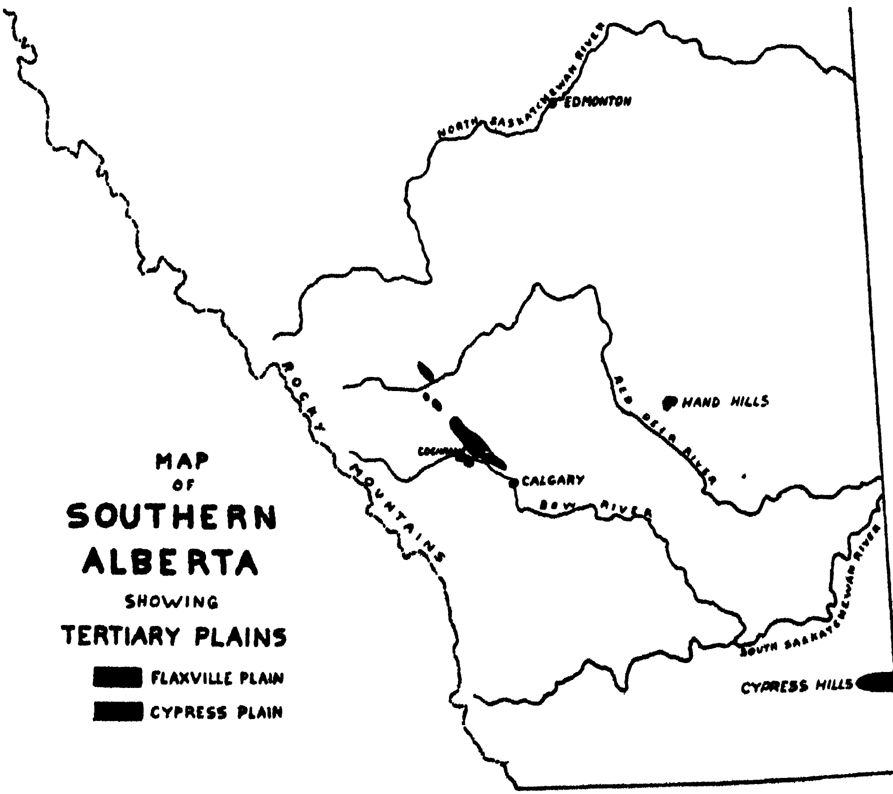
Introduction

The Tertiary history of Alberta is not well known. The reason for this lack of knowledge is that, so far as Alberta is concerned, it was a period of degradation rather than aggradation; a period of uplift with high land well supplied with rivers of sufficient gradient that little aggradation was possible. Further difficulties in reading the Tertiary history are provided by a severe glaciation in Pleistocene time, which produced a considerable change in the aspect of the country and left a heavy mantle of drift over much of the surface. The glaciation, therefore, not only affected the physiography of the area but effectively concealed the underlying rock over a greater part of the country. It is a combination of these circumstances that makes the Tertiary history of Alberta so difficult to read.

The history of the early Tertiary in Alberta is fairly well known. The early phase was very similar to, and formed a continuation of, the late Cretaceous history. The Cretaceous sea had been driven off and continental beds succeeded marine beds before that period came to an end. Continental conditions of deposition continued in Paleocene time with only a minor break intervening. The Paskapoo sandstone, very similar to the late Cretaceous Edmonton sandstone, was deposited over a greater part of Alberta at this time. It has suffered considerable erosion since and the formation is now limited to central Alberta with an outlier in southeastern Alberta and southwestern Saskatchewan known as the Ravenscrag formation. So far as known no deposits were laid down in Eocene time in Alberta. It was undoubtedly a period of uplift and erosion and it was at this time that the Canadian Rockies were formed. The culmination of this uplift was undoubtedly at the end of Eocene time or the beginning of Oligocene time as the first erosional debris known to have been derived from the Rockies was deposited on the plain to the east in Upper Eocene and Lower Oligocene time. These are the Swift Current Eocene conglomerate in central Saskatchewan[1] and the Cypress Hills Oligocene conglomerate which overlies the Ravenscrag formation

[1]Russell, L. S., An Upper Eocene vertebrate fauna from Saskatchewan: Trans. Roy. Soc. Can., Vol. 27, Sec. 4, 1933.

on Cypress hills and farther east on the Swift Current plateau. These formations are composed largely of well-rounded quartzite boulders, mixed with sandy beds and a certain amount of lime. The age of these beds has been definitely established by fossil evidence.



From Lower Oligocene time till the Pleistocene glaciers covered Alberta, the geological history of Alberta is largely unknown except that a great deal of erosion took place. The Cypress Hills conglomerate now stands at an elevation of from 1,500 to 2,000 feet above the present land surface. These remnant hills, capped by conglomerate, mark the elevation of the land surface, undoubtedly a plain, that existed just after the Rockies were elevated. It was named by Alden, the Cypress plain.[2] During the remainder of Tertiary time the Cypress plain suffered erosion till the land was reduced to the present level. Whether this erosion took

[2]Alden, W. C., Physiographic development of the Northern Great Plains: Geol. Soc. Amer., Bull. Vol. 35, p. 392, 1924.

place in one or two cycles is the question we are attempting to answer in this communication.

PREVIOUS WORK IN NEIGHBOURING AREAS

Though the details of Late Tertiary history are largely unknown in Alberta, some contiguous areas have been more fortunate. Bailey Willis,[3] working on the Lewis and Livingstone ranges in Montana, found the remnants of a high level plain in that area which he designated the Blackfoot plain. The Blackfoot plain has been studied by later workers, notably Alden[4] and Billings.[5] The plain attains an altitude of about 6,000 feet near the front ranges, standing some 500 feet above the stream levels and is overlain by quartzite boulders derived from the mountains and above this, glacial drift. Remnants of the Blackfoot plain in eastern Montana are known as the Flaxville plain and the quartzite boulders which cap the plain, the Flaxville gravels.[6] There may be some uncertainty as to the correlation of these two plain remnants as fossils have not as yet been obtained from the Blackfoot gravels. Fossils from the Flaxville gravels demonstrate their age to be "not older than Miocene or younger than Lower Pliocene".[7] Correlation is based largely on the altitude of the plain which rises to a height of 6,000 feet or more near the front range to 2,600 feet in central Montana. The Blackfoot or Flaxville plain (Alden, 1932, accepts the name, Flaxville, for this plain as it occurs in the front ranges) is from 600 to 1,500 feet below the elevation of the Cypress plain in central Montana.

The Flaxville plain extends into Saskatchewan on the Boundary plateau as shown by Collier and Thom's map. Another Saskatchewan point where quartzite gravels have been found on a high bench is Wood mountain.[8] These gravels are at a little higher elevation than the Flaxville gravels to the south. It is quite possible that Wood mountain is part of the Flaxville plain. The fauna in the Wood Mountain gravels is considered to be Miocene in age.

[3]Willis, Bailey, Stratigraphy and structure, Lewis and Livingstone ranges, Montana: Geol. Soc. Amer., Bull. Vol. 13, pp. 305-352, 1902.

[4]Alden, W. C., Physiography and Glacial Geology of Eastern Montana and adjacent areas: U.S. Geol. Surv., Prof. Pap. 174, 1932.

[5]Billings, M., Physiographic relations of the Lewis overthrust in Northern Montana: Amer. Jour. Sc., Vol. 35, pp. 260-272.

[6]Collier, A. J. and Thom, W. T., Jr., The Flaxville gravel and its relation to other terrace gravels of the northern Great Plains: U.S. Geol. Surv., Prof. Pap. 108(J), 1918.

[7]Gidley, J. W. *in* Collier and Thom, *op. cit.*, p. 181.

[8]Sternberg, C. M., Miocene gravels in Southern Saskatchewan: Trans. Roy. Soc. Can., Vol. 24, Sec. 4, p. 29, 1930.

FLAXVILLE PLAIN IN THE FOOTHILLS REGION

In considering possible remnants of the Flaxville plain in the foothills region in Alberta, it should be mentioned first that Alden thinks it possible that the top of Milk River ridge in southern Alberta, in tp. 3, rgs. 17-21, west 4th mer., may represent a remnant. It is a little low, 4,100-4,300 feet above sea level, and there are no known boulder deposits on the top. He also mentions a plateau in rgs. 21 and 22 west of the same meridian extending across the international boundary into Montana and standing at an elevation of 4,360 feet.[9] These areas have not been visited by the writer and will not be considered further at this time. Evidence from areas farther north are more pertinent to the subject of this paper.

West of Calgary extending from the northwest corner of tp. 25, rg. 4, west 5th mer. and in the northeast corner of tp. 25, rg. 5, west 5th mer., a flat plateau truncates steeply dipping beds. This is named the Crawford plateau. It slopes gently to the east, attaining an elevation of 4,350 feet on the east end and 4,400 feet on the west end—a distance of about three miles. Three patches of quartzite boulder conglomerate occur on this plateau as mapped by Hume.[10] This conglomerate seems to be identical with the quartzite gravels on the Flaxville plain in Montana and the height of the Crawford plateau conforms very well with the elevation of the Flaxville plain at a similar distance from the mountains.

A little to the north and west of the Crawford plateau, on the south side of tp. 26, rg. 5, another small plateau truncates the tilted and folded beds of the foothills. This is the Radnor plateau. It is about three miles long and from a quarter to a half mile in width. Its elevation at the east end is about 4,400 feet and at the west end about 4,450 feet. It is well grassed over and no beds of quartzite conglomerate have been observed.

There seems little doubt that the Crawford and Radnor plateaux represent remnants of the Flaxville plain as developed in the foothills in Montana. They occur at about the same elevation as the Montana remnants which occupy the same relationships to the front ranges of the Rockies, and the Crawford plateau is overlain by patches of quartzite conglomerate similar in every way to the quartzite conglomerate lying on the plateaux in Montana. The fact that no consolidated conglomerate has been observed on Radnor plateau does not mitigate against its inclusion as a remnant of the Flaxville plain. Aggradation on such a plain would be very irregular and only areas near the main drainage systems would receive heavy deposits of boulders. Again, since the time of uplift

[9]Alden, W. C., *Op. cit.*, p. 14.
[10]Hume, G. S., Geol. Surv. Can., Map 277A, Jumpingpound sheet.

of the plain erosion was active and much of the aggraded material on the plain must have been removed.

Nichols[11] has suggested that these plateaux are remnants of the Cypress plain and that the quartzite conglomerate on Crawford plateau is Cypress conglomerate. Such a suggestion is untenable as the Cypress plain must have been at least 2,000 feet above the elevation of these plateaux if we allow a sufficient slope to aggrade the Cypress hills in eastern Alberta which stand now at an elevation of 4,850 feet, which is above the level of the plateaux in the foothills. There seems little doubt, therefore, that we must correlate the Radnor and Crawford plateaux with the Flaxville plain as developed in the foothills in Montana.

Other evidences of the Flaxville plain are present in the Alberta foothills to the north of Crawford and Radnor plateaux.

North of Bow river occurs the largest segment of this plateau anywhere observed. This may be termed the Cochrane plateau. Commencing at Little Red Deer river in the northwest corner of tp. 28, rg. 5, west 5th mer., it extends southeast to the southwest corner of tp. 35, rg. 1, west 5th mer., a distance of about 34 miles. It is irregular in shape and cut by transverse rivers into three sections, the southeast section being known as Big Hill. At the northwest end it is over 4,500 feet in elevation, sinking to 4,000 feet at the southeast end. This plateau truncates the folded beds of the foothills on the west side. Quartzite boulders are quite abundant in places over the surface but no consolidated bed has been observed. Most of the area has been covered by glaciers from the Keewatin area and morainic material is locally quite abundant. No glaciers from the mountains, however, appear to have reached this elevation. Such glaciers seem to have been confined to the main river valleys or to have shoved up their tributaries as it is only in such low areas that good terminal moraines composed of mountain material have been observed. The quartzite boulders that lie on the high ridges and plateaux in the foothills undoubtedly have their source in the quartzite conglomerates laid down on the Flaxville plain.

In the area around Bow river, it is possible to get an idea of the slope of the Flaxville plain in an east-west direction. From the west end of Radnor plateau to the east side of Big Hill, a distance of about 17 miles, the drop in elevation to the east is about 350 feet or about 20 feet to the mile. The gradient would undoubtedly be steeper toward the west and more gentle toward the east as we would expect the uplift to be differential, increasing toward the west as it is in Montana.

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[11]Nichols, D. A., Terminal moraine of the Pleistocene ice-sheets in the Jumpingpound-Wildcat Hills area, Alberta, Canada: Trans. Roy. Soc. Can., Vol. 25, Sec. 4, 1931.

The elevation of the Flaxville plain in this area is about 600 feet above the level of Bow river, the main drainage way. This corresponds well with some of the elevations above the main drainage systems in Montana.

Commencing just north of Red Deer river, in sec. 34, tp. 31, rg. 7, west 5th mer., a high plain extends in a northwesterly direction to James river, ending in tp. 33, rg. 8. It is at least 12 miles in length and from one to two miles in width. The plain truncates the highly dipping, folded and faulted Cretaceous sandstones and shales and stands at the same elevation as the top of the foothill ridges in the vicinity. Unfortunately, a good portion of the area occupied by this remnant of plain has not as yet been topographically mapped.

The writer first came in contact with the remnants of the Flaxville plain in the area north of the Bow in the vicinity of Red Deer river, and extending into tp. 33, rg. 8. It is very irregular in shape and unfortunately much of it is unmapped. The plain is poorly drained and is quite marshy with a heavy growth of small trees including many willows. Though quartzite boulders are prevalent in the vicinity of the plain, no considerable bed of them could be found. The elevation of this plain is about 4,700 and 4,750 feet and stands 700 feet above the present level of Red Deer river. The elevation of this plain and its elevation above the present drainage system undoubtedly serves to correlate it with the Flaxville plain.

Standing on top of this remnant of the Flaxville plain at Red Deer river, one is impressed with the fact that the knife-like foothill ridges, representing successive fault blocks of hard Cretaceous sandstone, extending north and south from this remannt, are all about the same elevation as the plain itself, that is about 4,700 feet in this vicinity. They gradually decrease in elevation toward the east and increase towards the west. It becomes increasingly apparent that the tops of these ridges represent the elevation of the Flaxville peneplain. The occurrence of occasional quartzite boulders derived from the mountains lying on top of these ridges is added proof that they represented the elevation of the Flaxville plain. As the top of the foothills ridges has never been glaciated, these boulders must represent the remains of the aggraded material from the mountains which covered the Flaxville plain and is still found lying on its remnants.

Another area which shows a remnant of the Flaxville plain is south of Red Deer river in the southwestern part of tp. 30, rg. 7, west 5th mer. It covers several square miles and stands at an elevation of from 4,750 to 4,850 feet. Structurally it is farther west than the area north of the Red Deer, that is, it is closer to the mountain front and consequently higher in elevation. In the northwest corner of the same township and range

a small remnant of the same plateau, still closer to the mountain front has an elevation of over 5,000 feet.

The writer has not studied, in detail, the two remnants of the Flaxville plain south of Red Deer river and consequently has no knowledge concerning the aggraded material, if any, accumulated on them. Quartzite boulders from the mountains are, however, quite common in Fallen Timber creek in their vicinity and it is very probable that they were derived from quartzite boulder beds on the Flaxville plain, as Fallen Timber creek does not head in the mountains and it is very improbable that a glacier from the mountains ever occupied its valley.

The position and extent of the remnants of the Flaxville plain in the vicinity of Red Deer river, so far as they are mapped, are well shown on the following sheets of the Topographical Survey: Bearberry sheet (west half) No. 404A, and Fallen Timber sheet (west half) No. 406A. These isolated remnants show that the slope of the plain was from the west to the east but the data are yet insufficient to arrive at any accurate figures regarding the gradient.

REMNANTS OF THE FLAXVILLE PLAIN EAST OF THE ROCKIES

As it seems to be pretty well proven that the Flaxville plain is represented by high benches in the foothills area, it is interesting to examine the plains area to the east for some remnants of the same plain. It has already been mentioned that remnants of this plain have been found south of Cypress hills. These have not been studied by the writer and will not be included here.

In the area north of Cypress hills there are various hills of different elevations but only one which is capped by quartzite gravels. This is Hand hills, whose summit lies in tp. 30, rg. 17, west 4th mer. It lies about 160 miles northwest of Cypress hills and about 120 miles from the front of the Rockies and stands at an elevation of 3,500 feet. Hand hills are overlain by sand and marls and capped in places with quartzite conglomerate. The resemblance of these beds to those capping Cypress hills was so close that the have always been mapped as Oligocene and are so shown on current maps. A careful analysis of elevations, however, shows that such a correlation is not tenable. The Hand hills lie thirty miles nearer the front ranges of the Rockies than the Cypress hills and are over 1,000 feet lower in elevation, whereas, according to their position, they should be higher. It is interesting to notice the relationship, according to elevations, of the Flaxville plain and the Cypress plain as it has been worked out in Montana, according to Alden.[12] He states that the differ-

[12]Alden, W. C., *Loc. cit.*, p. 13.

ence in elevation "amounts to about 700 to 1,000 feet east of mer. 109 W and 1,000 to 1,500 feet west of this meridian, possibly 2,000 feet in the Rocky Mountains of Glacier National Park, and 3,000 feet or more north east of the Yellowstone National Park". As the west end of Cypress hills stands at an elevation of 4,850 feet and Hand hills at 3,500 feet and both localities fall in Alden's area west of the 109th meridian, the difference in elevation between the two hills —1,350 feet - agrees remarkably well with Alden's figures of 1,000 to 1,500 feet for the area, and demontrates that the gravels on top of Hand hills should be correlated with the Flaxville gravels and not with the Cypress Hills gravels and that Hand hills must be considered as a remnant of the Flaxville plain and not of the Cypress plain.

AGE OF THE FLAXVILLE PLAIN IN ALBERTA

No fossil evidence has so far been obtained from the aggraded deposits on the remnants of the Flaxville plain in Alberta. In Montana, fossil evidence seems to show aggradation was proceeding on this plain in Upper Miocene to Lower Pliocene time and possibly still later.[13] In southern Saskatchewan, the Wood Mountain beds, which may be correlative with the Flaxville gravels contain a Miocene fauna.[14]

The writer would consider that a late Miocene age for the Flaxville plain is more probable, taking into consideration the amount of erosion that has taken place since its uplift. The earliest fauna present in the gravels is more likely to date the aggraded beds as it is certain that animals roamed the plain since the uplift and it would not be unlikely to find the bones and teeth of such later animals mixed with the boulders on the plain, perhaps locally reworked.

CONCLUSIONS

The facts seem very clear that over the general area of Alberta the Cypress plain had been eroded down pretty well to base level by the end of Miocene or the beginning of Pliocene time. A general uplift then took place, undoubtedly centering in the Rockies, which raised this peneplain and started another erosion cycle. This peneplain, known as the Flaxville plain in Montana, is represented today by various remnants in the foothills and plains of Alberta as described in this paper.

[13]Collier, A. J. and Thom, W. T., Jr., The Flaxville gravel and its relation to other terrace gravels of the Northern Great Plains: U.S. Geol. Surv., Prof. Pap. 108, pp. 179-183, 1918.

[14]Sternberg, C. M., Miocene gravels in Southern Saskatchewan: Trans. Roy. Soc. Can., 3rd Ser., Vol. 24, Sec. 4, pp. 29-30, 1930.

In conclusion, the writer would like to point out that the few remnants of the Flaxville plain noted in this paper are not intended to be a complete record of all such remnants in the province. Many areas have not been investigated as much of the foothills area has not as yet been topographically surveyed. It is the intention at this time merely to bring forward sufficient evidence to prove the presence of the Flaxville plain in this area and so to add another chapter to the Tertiary history of Alberta.

TRANSACTIONS

OF THE

Royal Canadian Institute

Missing No I

No. 50 OCTOBER, 1941 VOL. XXIII, PART 2

198 COLLEGE STREET
TORONTO, CANADA

CRETACEOUS MARINE FORMATIONS PENETRATED IN WELLS NEAR LLOYDMINSTER, SASKATCHEWAN

By R. T. D. Wickenden[1]

For several years there has been much drilling for oil and gas in the vicinity of Lloydminster, Saskatchewan. Since most of the drilling was done with standard rigs the samples obtained from the various formations show little contamination, and much good material has been obtained for studying the stratigraphy of the area.

The area is located along the Alberta-Saskatchewan boundary about 300 miles north of the International boundary.

Two reports, one by Hume and Hage,[2] and another by Edmunds,[3] have recently been published about the area. These reports are mostly concerned with the occurrence of oil and gas and the stratigraphy is incidental to this. The present paper is confined to details of the stratigraphy of part of the formations and correlations based on the study of lithology and micro-faunas.

All the wells have been drilled to the top of sands assumed to be of Lower Cretaceous age and only a very few have been made deeper. Because of lack of information about the deeper formations this paper is confined to the formations above the Lower Cretaceous sands.

The following table lists the formation discussed here:

Formation	Lithology	Thickness in feet
Grizzly Bear..................	Shale	?
Ribstone Creek..........	Shale and sand	100?
Lea Park....................	Shale	Average 820, varies from 790 to 870
Alberta......................	Shale	Average 670, varies from 660 to 690

Below these formations are about 300 feet, more or less, of sands with a few shale bands in some of the wells.

The log of the Lloydminster, No. 3 well, is published here to give details of the lithology of a typical well.

[1]Published with the permission of the Director, Mines and Geology Branch, Department of Mines and Resources, Canada.

[2]Hume, G. S., and Hage, C. O., Lloydminster Gas and Oil Area, Alberta and Saskatchewan, Geological Survey (Canada) Paper 40-11, 1940.

[3]Edmunds, F. H., Oil and Gas in Lloydminster Area. Can. Min. Met. Bull. No. 338, June, 1940, pp. 261-278.

LLOYDMINSTER No. 3

Location L.S. 16, Sec. 26, Tp. 49, R. 28, W. of 3.

Formations	Depth in feet	Lithology, Accessory Material and Remarks	Microfossil and Correlation
	0–80	Missing, probably mostly glacial drift	
Grizzly Bear?	80–90	Shale medium grey, some glauconite, some glacial drift.	Marine shale member in Foremost of southern Alberta
	90–100		
	90–100	Shale medium grey, some glauconite, Foraminifera.	
Ribstone Creek?	100–120	Shale sandy, medium grey, some glauconite, Foraminifera.	
	120–140	Shale, medium grey, Foraminifera.	
	140–150	Missing.	
	150–180	Shale medium grey, traces of plant remains, few Foraminifera.	
	180–190	Missing.	
	190–200	Shale medium grey, traces of plant remains, Foraminifera.	
?	200–230	Cement, some traces of shale, few Foraminifera	
Lea Park	230–320	Shale medium grey, Foraminifera, a little pyrite.	
	320–330	Shale medium grey, some grey sandstone.	
	330–340	Shale medium grey, Foraminifera.	
	340–350	Shale medium grey, some grey sandstone.	
	350–380	Shale medium grey, a little pyrite, few Foraminifera.	
	380–400	Shale medium grey, a little grey sandstone, Foraminifera, a little pyrite.	Pakowki?
Upper Members	400–410	Shale medium grey, little pyrite, Foraminifera, trace of glauconite.	(Southern Alberta)
	410–420	Shale medium grey, some ironstone concretions.	
	420–510	Shale medium grey, Foraminifera, a little pyrite.	
	510–520	Shale medium grey, ironstone concretions, Foraminifera, a little pyrite.	
	520–540	Shale medium grey, Foraminifera, a little pyrite.	
	540–580	Shale medium grey, Foraminifera, some ironstone concretions, a little pyrite.	
	580–760	Shale medium grey, Foraminifera, a little pyrite.	

Formations		Depth in feet	Lithology, Accessory Material and Remarks	Microfossil and Correlations
Lea Park	Lower Member	760–780	Shale medium to dark grey. *Epistomina caracolla*, etc., a little pyrite.	*Epistomina caracolla*
		780–920	Shale medium to dark grey, Foraminifera, some brownish ironstone concretion, a little pyrite.	Milk River Sandstone (Southern Alberta)
		920–960	Shale medium to dark grey, Foraminifera.	
		960–970	Shale medium to dark grey, ironstone concretions, Foraminifera.	
		970–980	Shale medium to dark grey, Foraminifera.	
		980–990	Shale medium to dark grey, fish remains, bentonite.	
		990–1010	Shale medium grey, little pyrite, fish remains, bentonite, Foraminifera, grey mottled concretions.	
Alberta		1010–1080	Shale dark grey with white calcareous specks, little pyrite, shell fragments.	Boyne Member (Manitoba) Niobrara (U.S.A.)
		1080–1100	Shale dark grey with white calcareous specks, little pyrite, shell fragments, some calcareous sandstone.	
		1100–1170	Shale dark grey with white specks, a little pyrite, shell fragment, Foraminifera.	
		1170–1180	Shale dark grey with white specks, a little pyrite, shell fragments, Foraminifera, much iron oxide probably from bit.	
		1180–1190	Shale dark grey, a little pyrite, Foraminifera, some light grey sandstone.	Morder (Manitoba)
		1190–1270	Shale dark grey with white specks, a little pyrite, shell fragments, Foraminifera.	Assiniboine -Keld (Manitoba)
		1270–1280	Shale dark grey with white specks, a little pyrite, shell fragments, Foraminifera, some light grey sandstone with glauconite.	
		1280–1290	Shale dark grey with white specks, a little pyrite, shell fragment, Foraminifera.	
		1290–1310	Shale dark grey, a little pyrite, shell fragments, some light grey sandstone.	
		1310–1320	Shale dark grey, a little pyrite, shell fragments, buff granular calcareous material.	Ashville (Manitoba) Fort St. John (Peace River District)
		1320–1350	Shale dark grey, little pyrite, grey concretions.	
		1350–1370	Shale dark grey, some brown granular calcareous material.	
		1370–1390	Shale dark grey, fossil fish remains.	
		1390–1410	Shale dark grey, fossil fish remains mostly replaced by pyrite, brown granular calcareous material.	

Formations	Depth in feet	Lithology, Accessory Material and Remarks	Microfossil and Correlations
	1410–1430	Shale dark grey, some crystalline pyrite, brown granular calcareous material.	Milliammina Zone
	1430–1450	Shale dark grey, some grey sand, Foraminifera.	
	1450–1460	Shale dark grey, brownish grey concretions.	
	1460–1470	Shale dark grey.	
	1470–1480	Shale dark grey, brown granular concretions.	
	1480–1500	Shale dark grey, brown granular concretions, some white sand.	
Alberta	1500–1510	Shale dark grey, some white sand, fish remains.	
	1510–1520	Shale dark grey, buff granular concretion, some white sand, fish remains.	
	1520–1550	Shale dark grey, grey concretions, buff concretions.	
	1550–1570	Shale dark grey, some buff granular concretions.	
	1570–1580	Shale dark grey, some buff granular concretions, grey sandstone, a little glauconite.	*Haplophragmoides gigas* (variety) Lower Cretaceous?
	1580–1610	Shale dark grey, a little grey sandstone, Foraminifera.	
	1610–1650	Shale dark grey, a little grey sandstone, a little glauconite, Foraminifera.	
	1650–1680	Shale dark grey, much sandstone, shell fragment, little glauconite, cher pebbles at 1680	
Lower Cretaceous	1680–1697	Sand, grey and white.	
	1697–1704	Shale and sand, grey.	
	1704–1707	Sand, light grey.	

ALBERTA FORMATION

The name Alberta was given to a formation in the foothills by Hume.[4] In the type area the formation includes 3 members, the lower Alberta shale with the *Inoceramus labiatus* fauna, the Cardium, a sand and conglomerate member in the middle, and the upper Alberta, a shale member. The Upper Alberta contains fossils of Montana age near the top, whereas the rest of the formation contains fossils of the Coloradoan age.

Hume considers that the same name[5] applies to the formation in the Ribstone area that occurs between the Lea Park formation, above, and

[4]Hume, G. S., Geol. Surv. Canada, Summ. Rept. 1929, Pt. B, pp. 6B-10B, 1930.

[5]Hume, G. S., Oil and Gas in Western Canada, Geol. Survey of Canada, Econ. series, No. 5, p. 198, 1933.

sand formations of probable Lower Cretaceous age below. The same name is used for this series of beds in this paper although it is probable that the term should be more restricted in this area as will be mentioned in the discussion of the formation in this paper.

There are several lithologic and micro-fauna zones in the beds included in the Alberta formation as found in the wells near Lloydminster. The lowest zone is based on the occurrence of a micro-fauna, the most conspicuous species of which is a variety of *Haplophragmoides gigas* Cushman. Most of the specimens of this species found in these wells are smaller than the type used by Cushman. In other areas the smaller variety seems to occur at a little higher stratigraphical zone than the larger typical specimens. The top of the micro-fauna zone is about 100 feet to 130 feet above the base of the Alberta.

The lithology of this part of the formation is dark grey non-calcareous shale with some grey sandstone and glauconite. Usually there are a few chert pebbles ten to fifty feet above the base of the formation.

The basal zone differs from the next higher zone in the marked quantity of sand it contains and the lack of concretions. There is some doubt about the age of this part of the formation.

It has been pointed out that[6] *Haplophragmoides gigas* occurs in the Lower Cretaceous and while it is not impossible that the species may range into the Upper Cretaceous its presence in the beds included in the Alberta in the vicinity of Lloydminster suggests that some of these beds may be older than Upper Cretaceous.

Above the *Haplophragmoides gigas* zone is a slightly different lithological zone characterized by the occurrence of a small micro-fauna, the most distinctive species of which is *Milliammina manitobensis*. The highest occurrence of this species is about a hundred and fifty feet above the *H. gigas* zone. It is probable that *Milliammina manitobensis* occurs at lower horizons in other parts of the prairies but its upper limit seems to be much the same in all parts of the prairies.

The species associated with *Milliammina manitobensis* in the Lloydminster area seem to be much the same as those associated with it in the Ashville beds of Manitoba and in the Fort St. John formation near Peace River town.

The *Milliammina manitobensis* horizon is made up of dark grey or black non-calcareous shale with only a few beds of fine white sandstone. These beds also have buff, brown and grey concretions.

Above the *Milliammina* zone there is about one hundred and twenty feet of non-calcareous shale which contains some poorly preserved arenaceous Foraminifera and a few easily recognized species such as *Tritaxia*

[6]Wickenden, R. T. D., Trans. Roy. Soc. Canada, vol. 26, sec. 4, p. 179, 1933.

manitobensis and a fairly large rotund species of *Trochammina*. The *Trochammina* seems to be confined to the upper part of the zone.

The lithology of this zone is very much like that of the *Milliammina* zone except that there are very few large concretions but there is some brown granular calcareous material which looks as if it might be of secondary origin.

This zone is much like the upper part of the Ashville in its Foraminifera and its position immediately below the speckled shale zone.

The next zone occurs above the non-calcareous shale already mentioned below, and the Lea Park formation. There are three subdivisions to the speckled shale zone. The lowest member is made up of speckled shale which is a dark grey shale with specks of calcareous material. The samples from some wells contain fragments of limestone and it is probable that there are some thin bands of limestone in this member. Microfauna consists of only two or three species of Foraminifera. The two dominating species are *Globigerina cretacea* d Orbigny and *Gumbelina globifera* Reuss; both these species are supposed to occur in much of the Upper Cretaceous, but in the material studied from the prairies elsewhere they always occur with other species and never as abundantly as they do in this part of the section. This calcareous shale zone is eighty to one hundred feet thick.

Overlying the lowest speckled shale zone is a non-calcareous shale ten to thirty feet thick which grades into speckled shale at the top. The samples from some of the wells show a certain amount of specked shale which probably has caved from the high zone and this makes it difficult to judge the exact thickness of this member. There are usually a few Foraminifera in this non-calcareous shale but they are species whose range extends into the overlying calcareous shale.

The upper speckled shale member is about one hundred and forty feet to one hundred and sixty feet thick. Usually there is a fairly good fauna of Foraminifera in the lower part of this upper speckled shale member. The most common species are *Planulina kansisi* Morrow, *Gaudryina rugosa* d'Orbigny, *Loxostomum tegulata* Reuss, and a species of *Haplophragmoides* which resembles *Haplophragmoides glabra* Cushman and Waters although the periphery of the Canadian species is much more acute. These species and others found in this part of the formation are similar to those found in part of the Boyne beds of Manitoba and eastern Saskatchewan. This similarity of faunas and lithology to the Boyne beds suggest there is a correlation between this zone and the Boyne and if this is true the upper speckled shale zone of the Lloydminster wells includes the *Scaphites ventricosus* zone.

The upper one hundred and twenty feet of this speckled shale zone

are almost barren of Foraminifera except for a few specimens of *Globigerina* and *Gumbelina*.

The two bands of speckled shale with a non-calcareous shale between and the micro-fauna of this whole zone suggest that this part of the Alberta formations represents in descending order the Boyne, Morden and Assiniboines and Keld beds as exposed along the Manitoba escarpment. There is no evidence to show whether or not the upper part of the Alberta shale as defined here includes any strata of Montanan age as is the case of the Alberta shale in the foothills. Evidence based on the micro-fauna of the upper part Boyne beds in Manitoba suggests that these beds are partly of Montanan age.

Since there are about one hundred and thirty feet of beds above the part of the formation in the Lloydminster area that are probably younger than beds which contain the *S. ventricosus* fauna it is probable that the Alberta formation in the Lloydminster does include beds of Montanan age.

The Lea Park formation overlies the Alberta and extends to the base of the Ribstone Creek formation. The formation was originally described from surface exposures and although only about the upper three hundred feet of the beds can be seen at the surface it was defined as including everything between the base of the Ribstone Creek and the top of the Colorado. The actual thickness of the beds was not known at the time the formation was named and it is only since more well samples have been studied that we have learned what is the thickness of these beds. In the Lloydminster area the Lea Park appears to be 800 to 870 feet thick. The thickness varies somewhat because the overlying Ribstone Creek formation is not so well developed and it too may be made up of marine deposits.

There are two parts to the Lea Park which differ in both lithology and micro-fauna. The lower part is made up of medium to dark grey shale with numerous concretions near the top of the section.

The basal fifty feet of the formation usually have several beds of bentonite and in some places calcareous mottled grey to white concretions.

The micro-fauna of the lower part of the Lea Park is distinguished by the presence of *Epistomina carocolla* (Roemer) throughout the section and near the base *Planulina taylorensis* (Carsey) and *Trochammina ribstonensis* Wickenden are fairly common. Other species include varieties of *Haplophragmoides*, *Lenticulina*, and *Loxostomum*. This assemblage resembles that described by Loetterle[7] from the base of the Pierre in Nebraska.

[7]Loetterle, G. J. The micropalaeontology of the Niobrara Formation in Kansas, Nebraska and South Dakota, Bull. 12, Second Series, Nebraska Geological Survey, 1937.

The micro-fauna is also similar to that found in the marine beds that replace the brackish and non-marine beds of the Milk River formation in southern Alberta. This part of the Lea Park is undoubtedly the marine equivalent of the part or all of the Milk River formation.

The upper part of the Lea Park formation is made up of medium grey shale for about 200 to 250 feet above the lower part. This shale is overlain by a similar shale with some irregular concretion bands and a little sandy shale in some wells. This part is usually about one hundred to one hundred and fifty feet thick. The uppermost part of the formation includes about 200 to 250 feet of shale usually without many concretions. There may be sandy shale or even sand beds in this part of the formation depending on where the boundary between the Lea Park and the Ribstone Creek formations lies. The upper contact with the Ribstone Creek is very indefinite because the sand assumed to be Ribstone Creek is in part marine in the Lloydminster area and not nearly all non-marine as in the area farther west where the formations were originally defined. The criteria for defining the boundaries between the two formations are not satisfactory. The total thickness of the upper part of the Lea Park that is between the Ribstone Creek formation and the part already described as the lower part of the Lea Park is between 560 and 600 feet.

The micro-fossils of the upper part of the Lea Park are not so well known. Many of the species also occur in higher formations and since there is not enough information available to determine which fossils are confined to the upper part of the Lea Park it is not advisable to name any characteristic micro-fossils.

Most of the species do not range into the lower part of the Lea Park. One species which is very characteristic of the beds above the lower part of the Lea Park is *Verneuillina bearpawensis* Wickenden. This species is very common to all the upper part of the Lea Park and does occur in some of the overlying formations.

RIBSTONE CREEK AND GRIZZLY BEAR

The occurrence and boundaries of these two formations in the Lloydminster area are somewhat uncertain. The Ribstone Creek at the type locality is said to consist of two sandy members with a shale bed between. This formation has no diagnostic fossils. A coal seam occurs in this formation and the formation is considered non-marine. In the Lloydminster wells the sand beds near the top of the well are tentatively assigned to the Ribstone Creek and the overlying shales to the Grizzly Bear. Both the sandstone and shale appear to be of marine origin. Whether or not these beds are properly correlated may be considered uncertain by the author.

Study of the micro-fossils in various wells in Alberta seems to indicate that a species of Foraminifera which resembles *Haplophragmoides rugosa* Cushman and Waters is very common in the beds assumed to belong to the Grizzly Bear formation. This species is also common in a marine zone in the base of the Foremost in southeastern Alberta and it seems probable that this horizon extends into southeastern Alberta and southwestern Saskatchewan, at least, and as far north as Lloydminster.

ON *SOLENOPORA COMPACTA* (BILLINGS) AND THE NEW VARIETY *SOLENOPORA COMPACTA OUAREAUENSIS*

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Royal Ontario Museum of Palaeontology

In 1862 Billings[1] described from the Black River formation of Paquette rapids, Ontario, under the name of *Solenopora compacta*, a fossil consisting of small sub-globular masses one to two inches in diameter with an apparent concentric and compact lamellar arrangement. Since the time that this fossil was first reported many views have been expressed with regard to its systematic position. Originally it was considered to be a stromatoporoid, later a coral, and then an alga.

The extensive synonymy given for this species by Nickles and Bassler[2] will indicate the confusion of ideas and the uncertainty of opinion concerning the exact affinities of this widespread Middle Ordovician form. For instance, listed under *S. compacta* are: *S. compacta minuta* Ami; *S. paquettiana* Ami; *Tetradium peachii* Nicholson and Ethridge; *S. spongioides* Dybowski; *Actinostroma trentonensis* Weller; and *S. compacta trentonensis* Brown. Recently Bassler added still another variety, *S. compacta cerebrum.*[3]

It is quite possible that a careful study of the type specimens used in the diagnosis of the various species included in the so-called *S. compacta* would reveal the presence of several unrelated species and possibly even different genera. The writer came to this conclusion after examining thin sections among the collections of the Geological Survey of Canada at Ottawa labelled *S. compacta* from Ottawa, Murray Bay, Quebec, and Lake Winnipeg, Manitoba; *S. paquettiana* from Ottawa; and *Tetradium peachii* from Scotland.

A conspicuous feature of these sections is the presence of structures resembling septa which suggest coralline relationships. These structures vary in character and abundance in the different sections as will be noted in the table on the following page.

In considering the specimens represented in the foregoing table it is thought possible that numbers 1 and 3 from Ottawa and Lake Winnipeg, where septa-like structures are well marked in tangential sections, may represent a stage in the development of a coral in which fission went on very rapidly, i.e., where growth was active. Typical vertical sections of this form show crenulated tube walls.

Number 2 from Murray Bay, where septa-like structures are practically absent, may represent a resting stage in the development of the colony. Here walls of the tubes in vertical section are decidedly crenulate

Species	Locality	Characteristics
1. *S. compacta*	Ottawa	Septa-like structures well marked, suggesting frequent division of tubes by fission.
2. *S. compacta*	Murray Bay	Septa-like structures almost absent.
3. *S. compacta*	Lake Winnipeg	Good septa-like structures present.
4. *S. paquettiana*	Ottawa	Incomplete tube walls which resemble septa.
5. *Tetradium peachii*	Scotland	Incomplete tube walls as in *S. paquettiana*

(Pl. III, fig. 3). In this specimen also large groups of smaller, more regular tubes are present that resemble maculae.

The other two specimens, numbers 4 and 5, differ in that the septa-like structures appear to be due merely to the incomplete nature of the tube walls.

In 1931 W. A. Parks[4] recorded *S. compacta* from several horizons in the Black River formation exposed along the Ouareau river near Joliette, Quebec. V. J. Okulitch[5] later confirmed its occurrence. An examination of Professor Parks's collection has led to the present study and to the establishment of the variety *S. compacta ouareauensis*, a description of which follows:

Solenopora compacta ouareauensis var. nov.

Plate III, Figures 1 and 2

External Features.—Irregular-shaped, compact, nodular masses as much as 35 mm. wide and 25 mm. high. Surface smooth. Concentric lines at regular intervals show distinctly on worn surfaces. These may be interpreted as successive stages of growth. *Internal Features.*—Tangential sections indicate an abundance of minute floriform tubes about thirteen of which appear in the space of 1 mm. The tubes, originally sub-angular, are rendered floriform by the development within them of structures that resemble septa. Tubes, which would seem to be mature, have six sides and three septa. All stages in the development of the organism, however, may be seen down to the earliest stage with exceedingly small angular tubes and no septa. Other stages show a meandering condition in which the tube walls are incomplete and in which adjacent tubes tend to merge.

Such a combination of features suggests a coral where growth takes place by fission. The sections under discussion resemble the genus *Tetradium* except for the exceedingly minute size of the tubes. The

meandering effect suggests the *Chaetetes radians* group of corals of the later Palaeozoic. Here again the small size of the tubes distinguishes the present form. Owing to the extremely small size of the tubes it is not easy to follow with accuracy the internal structures by means of serial sections and, therefore, the true nature of the so-called septa cannot be determined with any degree of certainty.

In addition to the above-mentioned characteristics tangential sections display here and there groups of special tubes which are more elongate and which tend to radiate.

Vertical sections show tubes with straight walls of a uniform thickness in which tabulae are sparingly developed. The tubes increase in size gradually from the initial portion. In the early part of the growth at least twenty-six can be counted in the space of 1 mm. whereas later only half that number appear in the same space. Figure 2, where two growth stages are superimposed, clearly illustrates this point.

This new variety differs from typical *S. compacta* (1) in the larger size of the tubes, (2) in the straight, non-crenulate walls and (3) in possessing fewer tabulae.

Remarks.— The algal nature of *Solenopora* is agreed upon by many students. The septa seem to resemble most closely those found in the genus *Tetradium* which genus has itself been considered by some to be an alga, though recent studies by Okulitch do not favour such an interpretation.[6]

Pia[7] regards *Solenopora* as an alga and includes it in a special family, *Solenoporaceae*, but draws attention to its doubtful algal nature. He mentions Pcelincev as advocating a position with the tabulate corals. But since the tabulate corals are now considered to be an unnatural class such a suggestion is of little significance. *Solenopora*, however, may fit into one of the many short-lived groups formerly included in the *Tabulata*.

The present study does not throw any further light upon the biological affinities of the species but it has been thought desirable to record the special features displayed by the Ouareau river form for it is only by understanding the variations within the species that we can ultimately hope to reach a more definite conclusion as to the natural relationships of this very common fossil organism.

Cotypes. 23356. Royal Ontario Museum of Palaeontology, Toronto, Ontario.

Occurrence. Black River limestone, Ouareau river, near Joliette, Quebec.

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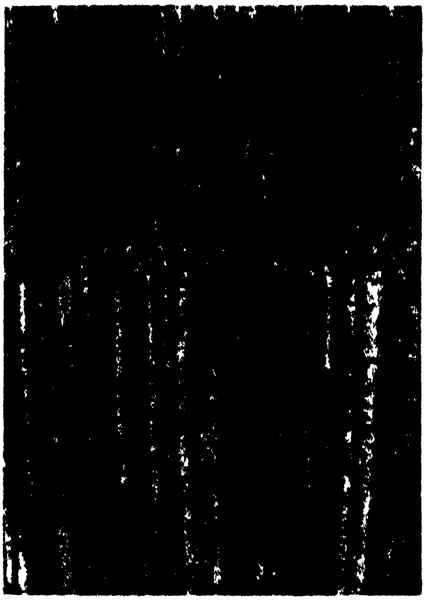
DESCRIPTION OF PLATE III

FIGURE 1.—*Solenopora compacta ouareauensis* Fritz var. nov. Vertical section X 33. Cotype Royal Ontario Museum Palaeontology showing two growth stages in which the tubes have straight walls and few tabulae.

FIGURE 2.—*Solenopora compacta ouareauensis* Fritz var. nov. Tangential section X 33. Cotype Royal Ontario Museum Palaeontology showing septa-like structures in the regular tubes; also, groups of elongate, radiating tubes.

FIGURE 3.—*Solenopora compacta* (Billings). Vertical section of specimen from Murray Bay, No. 878 Geological Survey Canada, Ottawa, showing crenulated tube walls and few septa.



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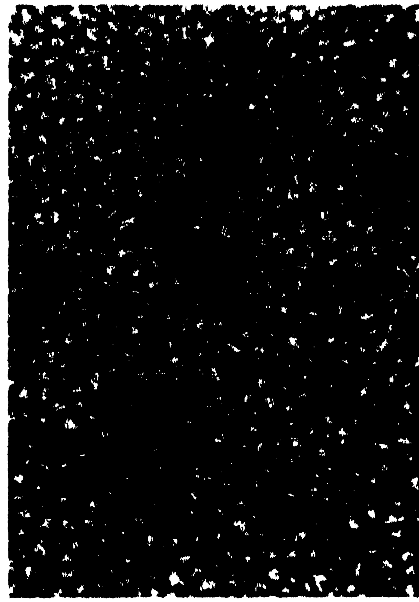

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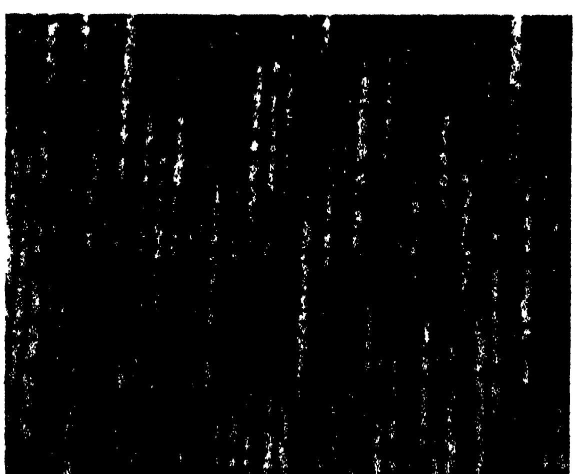

3

FRITZ: ON *SOLENOPORA COMPACTA* (BILLINGS) AND THE NEW VARIETY *SOLENOPORA COMPACTA OUAREAUENSIS*

NEEDLE BLIGHT AND LATE FALL BROWNING OF RED PINE (*PINUS RESINOSA* AIT.) CAUSED BY A GALL MIDGE (*CECIDOMYIIDAE*) AND THE FUNGUS *PULLULARIA PULLULANS* (DE BARY) BERKHOUT

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1. INTRODUCTION

During the last few years, plantations of red pine at several localities in southern Ontario have suffered intermittently from epidemic foliage maladies of novel character and unknown etiology. The first of these, which was called "needle blight" affected the lower part of the needles

of the current season, within the sheath of scales, where it caused decay leading to a conspicuous and characteristic crooking of the whole short shoot, and eventually to its death. The second, which was called "late fall browning", occurred later in the season and induced a remarkably sudden and severe browning of the foliage. Again only the shoots of the current season were involved, but so intense was the incidence that affected plantations appeared as if they had been run through by fire.

When first encountered in Ontario these maladies were the cause of considerable apprehension and puzzlement. Their very novelty and evident epidemic characteristics could not be regarded lightly, and no pertinent account could be found in phytopathological literature. The injury, whether on account of blight or browning, was sometimes severe and, if recurrent, threatened ultimately to bring about the death of trees attacked. Experience has not borne out the gloomy prognosis originally entertained, but it has shown that this fortunate eventuality was due to the operation of a natural control factor heretofore unknown.

A relation between needle blight and late fall browning was not at first suspected. Each disease, when typically developed, presented distinct and characteristic symptoms which were displayed at definite and separate times. A common causal circumstance has been discovered, however, in the ovipositing of a gall midge, from which initiation divergent courses of development lead to one or other of the above.

The following pages comprise a report of investigations of these virtually unknown maladies. True, gall midges have long been known to infest conifers, though none have been reported heretofore on red pine; but the pathological and epidemic phases of forest infestations by these insects have received scant attention. Thus the association of fungus with insect in pathogenesis, as in the case of the needle blight herein described, has scarcely been suspected. Again the importance of midges as forest pests is commonly assessed as slight. In the light of the investigations presently reported, it seems that this opinion may be justified only on account of the existence of parasitism of which we have been ignorant.

An elucidation of forest diseases involves the determination of their cause and course of development, and a demonstration of the basis of control. In connection with the etiological studies later described, it has been necessary to investigate both insect and fungus pathogens, and a considerable bulk of entomological and mycological papers has been reviewed. From these, matter immediately pertinent to the present work has been incorporated therein; but a larger amount of merely related matter has had to be excluded. Sufficient titles have been entered

in the bibliography to facilitate reference to an extensive and varied literature on *Pullularia pullulans*, and to some of the important taxonomical and biological studies of gall midges.

2. IMPORTANT LITERATURE

The diseases of the red pine here discussed have already been noted in phytopathological literature (12) (25) but no adequate account of them has been published. There exists, however, a small body of knowledge pertaining to forest epidemics caused by, or associated with, gall midge infestation of pines other than *Pinus resinosa*. In Europe, foresters have long been familiar with certain gall midges as forest pests, and accounts of them have been embodied for many years in the standard forest literature of Germany (27) (37). The most important species there are apparently *Diplosis pini* De Geer, which causes swelling and resinosis in the twigs of pines and *Thecodiplosis brachyntera*, which infests the short shoots causing stunting and basal swelling of the needles and defoliation. This insect was studied by Eckstein (15) in Germany, and more recently by Smólak (39), who described extensive browning of forest plantations in Czechoslovakia. Tubeuf has given the results of his own studies of *Diplosis pini* De Geer and other midges, and has reviewed the work of others in an important series of publications (42), (43), (44), (45).

A widespread and novel epidemic of pine browning was noted by Eckstein in 1930. He was at first unable to specify its cause. Butovitsch (10) published an account of a similar phenomenon and attributed it to a gall midge larva which he found in the foliage. He thought it differed from the well-known *Thecodiplosis brachyntera*. Prell (36), in the following year, described the malady as novel and thought too that it was caused by a gall midge which he named *Cecidomyia Baeri* from the larva alone, in the belief that it was a new species. He specified differences between this insect and *Thecodiplosis brachyntera* and described the effect of each on its host. He applied the cognomen "Nadelknickende Kieferngallmücke" to the *Th. Baeri* larva and "Nadelkurzende Kieferngallmücke" to that of *Th. brachyntera*. Tubeuf (44) speculated on the rôle played by an unidentified fungus which he found associated with the disease. He called the trouble "Krückstockkrankheit der Kiefernkurztriebe durch Cecidomyiose."

For most of the knowledge of American gall midges we are indebted to Felt, but as he himself has pointed out (18) there is very little information on these insects as forest pests. A few papers and published notes refer to species infesting pine foliage, and the damage they cause. Snow and Mills (40) studied the browning and defoliation of *Pinus*

radiata in California, caused by a gall midge which they described and named *Diplosis pini-radiatae*. An account of their work was published after Mills's death. Burke (10) recently referred to this insect under the name *Thecodiplosis pini-radiatae* as a serious pest. Peirson (34) noted widespread browning and subsequent defoliation of white pine in Maine which he attributed to the work of an unidentified gall midge larva. Felt (23) recently observed extensive and, at first, "mysterious" needle browning of white and Scots pine in Connecticut, due to a gall midge which he named *Cecidomyia* (*Itonida*) *pinifoliae*. Reference was made later to the work of this insect by Felt and Bromley (24). In 1939 a preliminary account by Haddow and Adamson (25) called attention to the diseases which are the subject of this paper. The opinion was expressed then that a gall midge caused "late fall browning" but that typical "needle blight" was due to infection by a fungus, *Pullularia pullulans*, following oviposition by a gall midge. The same year, Davis et al. (12) published a paper describing "needle droop" of red pine, observed in the lake states and elsewhere. The cause of the disease was not specified; but from the excellent written and photographic evidence given, Mr. Adamson and I were of the opinion that "droop" was the same as our "needle blight", an opinion confirmed by the examination of specimens which Dr. Davis kindly sent.

3. DISTRIBUTION AND IMPORTANCE

Needle blight and late fall browning were detected at Midhurst, Ontario, in 1932. Since then they have been seen at various localities in Simcoe, Durham and Victoria Counties, in plantations of red pine (*Pinus resinosa* Ait.) from five to twenty years old. According to Davis et al. (12), "needle droop" (which I have diagnosed as "needle blight") was first observed in Minnesota, Wisconsin and Michigan in 1935. In 1936 it occurred in a nursery in Maryland and in 1937 in a forest plantation in Massachusetts.

Observation in southern Ontario indicates that "needle blight" and "browning" as here understood are strictly of the red pine; for in plantations of mixed pines, only the red suffered. Similarly, pure plantations of white, Scots, and jack pine have remained completely unaffected, while contiguous red pine plantations suffered severely. Davis et al. reported that species other than red pine occasionally suffered a condition resembling "droop". Thus, white pine was occasionally affected in the lake states, and in the Pacific Northwest, ponderosa pine sometimes displayed the symptoms. Prell (36), Tubeuf (44) and Smólak (39) have described and illustrated a "droop" of Scots pine foliage in central Europe, which is comparable with what occurs here.

Whether in these several instances the etiology is precisely the same is questionable.

According to my own observations, no mortality has been suffered in Ontario on account of blight or browning. Most of the plantations in which the diseases have been seen, however, have been from ten to twenty years old. Such trees are less susceptible to killing by these diseases than younger ones, on account of their relatively smaller proportion of current season's foliage, which alone is attacked. Davis et al. reported serious mortality among young trees on account of droop. Some three and four year old plantations were almost completely destroyed, and the loss among affected trees less than six feet in height amounted to as much as forty percent. Larger trees suffered little if any mortality.

The injury to the current season's foliage is often very great. At Midhurst, the loss has been as much as seventy-five percent. It is obvious that repeated defoliation to such an extent could not be tolerated for many years. Only the non-recurrence of severe blight or browning has saved the plantations from serious mortality. These diseases are therefore potentially dangerous, and if introduced in the absence of controlling agencies would prove to be very destructive.

4. SYMPTOMS

(a) *General Characteristics*

Needle blight and late fall browning of red pine are diseases of plantations having been observed as epidemics only in close, even-aged stands, mostly ten to twenty years old. They have not been seen in the natural forests in Ontario, though isolated large native pines standing in a severely browned plantation were recently found diseased. In extensive plantations, affected areas are commonly more or less circular in shape and such zones have comprised as much as fifteen or twenty acres, though usually they have been of smaller size.

The intensity and the relative importance of each type of disease have fluctuated greatly from year to year. Needle blight has been most prevalent in wet seasons,—in fact its onset has always been associated with rainy weather, while late fall browning has been favoured by dry ones. Thus, in the notably hot and dry season of 1936, needle blight was almost completely absent at Midhurst, but late fall browning was prevalent and remarkably severe. Needle blight has been detected by its field symptoms as early as the latter part of July but has usually appeared in August. Fall browning, on the other hand, reaches its maximum intensity after the middle of October, and may not become apparent at all until early in that month.

(*b*) *Needle Blight*

In a plantation suffering an epidemic of needle blight over half the foliage of the current season (which alone is susceptible) may be affected. Both needles of the short shoot are involved, though rarely one may remain green temporarily. The needles are of normal or nearly normal length, but are sharply bent or hooked within the sheath of scales, the whole forming a crook, in which habit they hang until abscissed and cast. (Fig. 1, Plate IV; Fig. 10, Plate V). Normal needle fall, which comes from the inner (proximal) position on the boughs, passes in the main directly to the ground without much interference, but the blighted needles falling from the distal shoots are intercepted and tend to accumulate on the green foliage below. The tendency is aggravated on account of the crooking of the needle pairs, for such are easily caught and are retained very persistently. Thus, a blighted plantation exhibits a remarkably untidy appearance, the terminal shoots spike-like through loss of foliage, with awry needles attached, and the boughs littered with fallen hooked fascicles. The burden of needles on the ground beneath the trees is of course unusually heavy. With the spreading of new foliage the following spring, the damage is surprisingly well masked, and it will scarcely be detected by a casual observer. Within the individual tree, blight is distributed very uniformly, but with slightly heavier evidence towards the top. There too, the disease is more conspicuous than below, on account of the greater length of the shoots which, for the same loss of foliage, look more barren than do those lower down on the tree. On a single shoot the loss is greater from the lower part, which, in fact, is often completely bare. Towards the top at least a few fascicles persist, and commonly just below the buds enough remain to give the shoot a tufted appearance. (Plate 1, Fig. IV). Wherever blight has occurred repeatedly, the crowns present a very sparse appearance, on account of the loss of foliage from the long shoots of several years. There is evident, too, a dull cast to the trees over the whole affected area, which is due to the darkening of accessory foliar parts by the mycelium and spores of the fungus *Pullularia pullulans*. This organism, normally not uncommon, has become epidemic and can be found in great abundance on bud scales, needle sheaths and bracts supporting the short shoots. The long deciduous tips of these, which give to the new shoots their chaffy appearance in the spring, become recurved and darkened to an unusual degree, and often bear small fungus fructifications. In wet weather the sugary exudation of resin on the buds, and the fimbriated margins of bud and sheath scales become darkened over with a superficial growth of the fungus.

In such plantations there is commonly a good deal of extra-seasonal

growth. One or more of the side buds of the terminal cluster may break in the summer or fall and produce fall shoots a few inches in length. Many of these die within a year, without having fully expanded their foliage, but some persist and lead to a forking of the stem, either simple or multiple. Such deformations, however, rarely endure for many years. The tendency to centric growth is very strong in red pine in close plantations, and dominance is soon regained by one or other of the competing leaders. This was shown in the examination of a plantation which had been badly needle-blighted five years earlier. At that time the trees had developed many "precocious" shoots, but, when examined, less than two percent of them appeared likely to suffer permanent forking. Extra seasonal growth and forking in red pine as here noted was described by Jump (28) who suggested that a growth hormone from the fungus *Dematium pullulans* (=*Pullularia pullulans*) might be the cause of it. It may be remarked that "precocious" shoots often produce three-needled fascicles. Many of these were found in the blighted plantations at Orr Lake.

If, from the hooked fascicle of a blighted short shoot, the scales surrounding the needles are carefully removed, the injury may be examined. The lesion, which is at the curvature of the hook, is dark, necrotic and resinous, and involves meristematic or young tissue which is normally still soft and white. It may be almost a centimetre long. Below is a length of the youngest leaf tissue, which is not involved but which dies as a result of the partial or complete abscission of the short shoot. Above the lesion the needles gradually die and brown. As a result of infiltration of resin, the necrotic zone becomes brittle and it is then only with difficulty that the covering scales can be removed without breaking the needles.

In the fall (and particularly in the spring on overwintered material) small black erumpent sclerotia and anostiolate pycnidial fructifications of *Pullularia pullulans* (de Bary) Berkhout are borne on or at the margin of the lesion. This fungus is regularly yielded in culture by tissue removed from that region. Microscopic examination reveals the fungus massed in the mesophyll of the leaf. The vascular and transfusion tissues within the endodermal sheath, and the epidermis and hypodermal cells are largely free of it. Many of the latter, however, are discoloured, and a few harbour hyphae, as do occasional xylem elements. On the accessory foliar parts, the fungus occurs both superficially and internally. Hyphae in the lumina of the tracheid elements of sheath and bud scales run lengthwise, passing through pits to make H connections with parallel hyphae in adjacent cells. Uni- and multi-cellular spores occur singly, in small clusters and in dark compact masses. It has been

observed that from these and from the hyphal cells *in situ* bud spores (blastospores) are produced freely in nutrient solution, filling the lumen occupied by the mother cell.

Over a period of several years I have observed that, if the onset of needle blight is delayed, its symptoms approach those of the late fall browning to be described. This circumstance is related to the degree of maturity of the needles and hardening of their bases at the time of infection. Typical needle blight (droop) can occur only when they are still succulent, and capable of further growth. Thus, needle blight first detected in the last week of August remained atypical throughout the rest of the season. Few of the short shoots were well hooked, though many were bent very close to their bases. The needles browned and died throughout their length, but the necrotic zone inside the sheath was restricted to a very short basal section.

(*c*) *Late Fall Browning*

In its epidemic characteristics late fall browning resembles needle blight, though it occurs later in the season. The suddenness and intensity of its appearance are sometimes very remarkable. Within a few days whole plantations have changed from normal appearance to one as if they had been run through by fire.

The disease causes the death of needles which brown rapidly from the base upwards. Over seventy-five percent of the foliage of the current season may be involved. Browned needles retain their normal habit on the parent shoot and do not show the crooking characteristic of blight. An examination of the lower part within the sheath reveals no conspicuous necrosis and no exudation of resin, but in the late fall a hand lens will disclose a small cavity at the fused bases of the needles (Fig. 8, Plate V). If the examination is made earlier, just before the needles are browned and dry throughout their entire length, a minute reddish legless grub may be discovered conformably disposed in the cavity. Later the larva migrates outward and, tightly compressed between the needles and the sheath, sometimes causes a conspicuous lump thereon. An occasional tattered exit hole indicates an unusual means of escape. Most larvae proceed to the distal end of the sheath and drop to the ground.

Long before browning actually takes place it is possible to detect the incipient conditions. The egg of a gall midge can be exposed by careful dissection of an infested short shoot under a binocular microscope. In mid-June eggs were found between the innermost scales, near the base of the needles,—spherical, opaque, almost colourless bodies, becoming dull orange with age. On July 21st a young larva was seen on the

adaxial face of a needle base, close to the margin. It was appressed against a tiny papilla of tissue which had a viscid appearance.

Infested short shoots, still green, were collected in early September, and after being fixed in formalin-acetic-alcohol, their lower ends were embedded in paraffin, and cut serially on a sliding microtome. The sections were stained in safranin and light green. In these preparations the body of the infesting larva was seen in a position parallel to the needles at a level opposite the growing point between them. It lay between the innermost scales, ventrally against the abaxial face of a needle. Its anterior end (which was lowermost in position) rested below the point of division of the vascular supply to the needles in an enlarged cup-like cavity at the junction of scale with axis, as shown in Fig. 14, Plate VI. Mid and posterior sections of the larva *in situ* are shown in Figs. 15 and 16 respectively. There were no signs of fungus infection in the host or of abrasion caused by mouth parts or "breastbone" of the larva. The extravascular leaf tissue was grossly deformed, a peripheral layer adjacent to the larva being dead and flattened, apparently the result of friction or pressure. Occlusions of wound gum in many cells and large intercellular cavities or cysts indicated that the tissue was traumatic. In the side of the short shoot opposite that against which the larva lay, there was a distinct hypertrophy of the transfusion tissue, and a modification of the character of its component cells. The latter, besides growing to about twice their normal size, became sharply angled in transverse section, and developed well-defined bordered pits, thus showing clearly their tracheidal nature. This growth was reflected slightly in the external contour of the needle base (Figs. 15 and 16) and might be considered an incipient "basal swelling".

In examining short shoots in June and July with the aid of a binocular dissecting microscope of about thirty diameters magnification, minute wounds were often found in the soft basal part of the needles. To demonstrate these wounds, a suspected short shoot should be detached intact and cut through transversely immediately below the point at which the needles are fused. The pair can then be withdrawn and bared of any adhering scales. The wounds cause an interruption of the smooth contour of the needle bases, which is evident when the parts are viewed under strong light from a lateral source. An actual incision is visible as a minute yellowish stained slit. This is surrounded by a pale sodden zone, which may be half a millimetre in diameter. On a single needle, numerous wounds were found on both adaxial and abaxial surfaces. The marks were always close to the base, none being more than four millimetres therefrom. They were made by the ovipositor

of a hymenopterous parasite of the gall midge while engaged in vigorous and repeated probing for the hidden larva of its host.

It may be noted here that plantations infested by gall midges became conspicuously decked with spider webs, most of which probably belonged to a single unknown species. The webs were spun lightly over the pine shoots and caught both midges and their parasites.

5. ETIOLOGY

I. The Gall Midge

(*a*) *General Account*

Gall midges or gnats (*Cecidomyiidae*) are small Dipterous insects comprising a large family of very delicate flies with characteristic antennae and simple wing venation. The larvae are legless maggots, most species having a bifid chitinous process in the anterior ventral part of the body known as the "breastbone" or "anchor process' (13). They are mostly phytophagous, (some are mycophagous) and many (though by no means all) cause galls in their hosts. Gall formers are often housed in their galls until they emerge, by various means, as adults; other larvae leave the host to pupate in the ground. A high degree of host specificity is characteristic of the family as a whole.

Among its members are some well known and exceedingly destructive pests such as the Hessian fly and the wheat midge, which are capable of causing immense damage to céreal crops.

The classification of the *Cecidomyiidae* is based very largely on the characters of the adult male. Felt (22) has given a detailed key to the genera of the family, under the name *Itonididae*. The genus *Thecodiplosis* (to which specimens of the red pine midge were tentatively assigned by Dr. Felt) was instituted by Kieffer (29) who selected Schwägrichen's *Cecidomyia brachyntera* as the type species. Felt (20) gave descriptions of eight American species of *Thecodiplosis*, one of which had a pine as host.

The following is a list of the gall midges which have been reported as infesting the short shoots or needles of pines in America, and their hosts·

Gall Midge	Host
Dicrodiplosis gillettei Felt	*Pinus rigida* Mill.
**Cecidomyia pinirigidae* Pack.	" " "
†*Diplosis pini-inopis* O.S.	*Pinus virginiana* Mill.
**Diplosis brachypteroides* O.S.	" " "
Cecidomyia sp.	*Pinus edulis* Engl.
	Pinus monophylla Torr.

Thecodiplosis cockerelli Felt	*Pinus edulis* Engl.
Janetiella coloradensis Felt	*Pinus virginiana* Mill.
‡*Itonida pinifoliae* Felt	*Pinus Strobus* L.
	Pinus sylvestris L.
Thecodiplosis pini-radiatae Snow and Mills	*Pinus radiata* D. Don.
	Pinus muricata D. Don.
	Pinus sabiniana Douglas
	Pinus coulteri D. Don.
	Pinus sylvestris L.

Of the above, *Dicrodiplosis gillettei*, *Thecodiplosis cockerelli* and *Janetiella coloradensis* cause well-marked characteristic swellings at the base of needles of their hosts. Other species cause a less conspicuous hypertrophy, accompanied by stunting and twisting or bending of the needles, followed by death and browning. This is the type of injury which *Thecodiplosis pini-radiatae* causes in *Pinus radiata* as described and illustrated by Snow and Mills (40). It is similar to that which *Thecodiplosis brachyntera* often causes in the Scots pine, as described and illustrated by Tubeuf (43) and others. Tubeuf showed however that the abnormalities induced by that species were quite variable, particularly the amount of stunting and gall formation. It is noteworthy that Snow and Mills also reported a puzzling instance in which an infestation said to have been by *Thecodiplosis pini-radiatae* did not induce the usual symptoms. Although the needles browned and died, they were neither stunted, nor swollen at their bases. The injury to white pine, caused by *Itonida pinifoliae*, as described by Felt and Bromley (24) was of this character, and the late fall browning of red pine corresponds closely.

There remains the type of injury described by Prell (35) and called by Tubeuf (44) "Krückstockkrankheit." It is characterized by a sharp bending of the needles within the sheath of scales, and a crooking of the whole short shoot. The similarity of this malady of the foliage of Scots pine to needle blight or "droop" of red pine cannot be overlooked, and suggests a common etiology. Such, in fact, is believed to exist, but in the sequent fungus infection rather than in the identity of the insect pathogens. Tubeuf himself noted the presence of a fungus, (which he illustrated in photograph) on the needle bases. He did not

*According to Felt (18) one or both associated with needle stunting and basal swelling.

†According to Osten Sacken, possibly the same as *Diplosis pini* De Geer.

According to Williams (46) *D. pini-inopis* = *Cecidomyia resinicola;* attacks the needles.

‡According to Felt (15) possibly the same as *Thecodiplosis brachyntera* Schwägr.

identify it (other than as one of Allescher's Sphaeropsideen) but suggested that perhaps it was concerned in the cause of "crook disease". There can be little doubt that the fungus shown was *Pullularia pullulans*, and that "Krückstockkrankheit" of Scots pine is closely analogous with "needle blight" or "droop" of red pine.

Until critical comparative studies have been made it will not be possible to give a specific diagnosis of the red pine gall midge. Such studies will necessarily be based on the examination of a number of adult males and females, together with the immature stages of this and closely related forms. It is undoubtedly close to *Thecodiplosis piniradiatae* Snow and Mills, and *Th. brachyntera* Schwägr. The following description of an adult female, reared from a larva taken from red pine foliage, is offered for general typification: Total length extended about 4 mm; antennae, 1 mm; head and body, less ovipositor, 2.5 mm; antennae lightly haired, segments about 100 microns long and 40 microns wide at the slightly waisted basal part, the narrower vase-like neck about one quarter the length of the whole; abdomen uniformly reddish orange; ovipositor paler, yellowish, rather conspicuously haired, with fine erect bristles; terminal segment bilobed; wings rather closely marginally haired at first, becoming smooth; legs haired at first, becoming smooth; claws simple strongly curved. A larva, taken from red pine foliage in October was as follows: Length 2.75 mm; width 0.75 mm; colour reddish orange; body smooth, segments inconspicuous; breastbone dark brown, slightly expanded and darker in colour at the forward end, with a simple bifurcation.

(*b*) *Life History and Habits of the Red Pine Gall Midge*

At the time of the onset of browning in the fall, the larvae of the gall midge are still in the short shoots, as may be demonstrated by dissection or other means. If infested short shoots taken at this time are placed in an open box in a refrigerator at about 40° F. the larvae will begin to come out after a few days. What induces this migration is not known but in the field it begins before the needles have become thoroughly dry; no living larvae have been found in shoots of which the needles had become brittle. Periodic examinations at Midhurst and Orr Lake in 1939 indicated that many of the larvae left the trees by the middle of October, and that most of them had gone by the middle of the month. (Table No. 1.) On emerging from the sheaths they fell to the ground and then moved downward through the humus layer into the mineral soil, in which they came to rest at a depth of an inch or less.

Soil was taken for examination in mid-November from beneath a

plantation which had been heavily browned. The litter and humus layer were stripped off and examined separately. The mineral soil was of rather fine sand and silt, containing some gravel. It was partially dried and screened. Eighty percent of it was discarded, comprising thirty per cent which was retained by a 1/8 inch mesh and fifty percent passed by a 1/32 inch mesh. Twenty percent of the whole, retained by the 1/32 inch mesh, was spread thinly on a large sheet of white paper and examined with a suitably mounted reading glass. Four samples, each representing one square foot of plantation surface taken to a depth of one and a half inches yielded six, nine, ten and thirteen gall midge larvae respectively. None was found in the litter or humus.

TABLE No. 1

EXAMINATION OF FALL BROWNED SHORT SHOOTS

Locality	Date 1939	No. Examined	No. with basal cavity	No. containing Gall Midge Larvae	
				(Living)	(Dead)
Orr Lake Forest......	Oct. 10	50	50	44	2
" " "	Oct. 18	50	50	36	0
" " "	Oct. 31	50	50	20	0
" " "	Nov. 11	50	50	0	0
Midhurst.......... ..	Oct. 14	108	108	27	0
"	Oct. 16	100	100	0	3
"	Nov. 17	72	72	0	0

In the spring, the gall midge emerges as an adult. This was shown directly by trapping in an infested plantation. In early May a metal wash tub, in the bottom of which several one inch circular holes had been cut, was inverted on the ground and the rim packed lightly with soil. Over each hole was placed a small tin funnel which was fixed to the tub with plasticine. The stem passed through a cotton plug into a wide-mouthed Ehrlenmeyer flask. Two gall midges and five chalcid fly parasites were taken from these traps on June 5th.

The time of emergence and the duration of the flight period is best indicated by the record of tanglefoot traps which were exposed at Midhurst during the season of 1939 (see Table No. 2). A sheet of oiled stencil paper, 8″x10″, was coated on one side with tanglefoot substance, rolled into cylindrical shape with the sticky side out, and mounted on a bamboo pole. Two such traps were set at tree height (about twelve feet) in a plantation which had been badly infested the season before. The sheets were changed daily, or at convenient intervals from early May till mid-July, and were examined under a suitably mounted lens.

Among the insects caught, gall midges were recognized with a good deal of certainty by their general characteristics, and particularly by the colour of the abdomen, which showed clearly on the sheets. In view of the known epidemic conditions prevailing, it is believed that most, if not all of the midges caught represented the species infesting red pine. The numerous chalcid fly parasites caught were well preserved and easily recognized. They were mostly *Platygaster filicornis*.*

TABLE No. 2

RECORD OF TANGLEFOOT TRAPS—MIDHURST

Exposure Period (1939)	Trap No. 1 — Number Caught Midges	Trap No. 1 — Number Caught Parasites	Trap No. 2 — Number Caught Midges	Trap No. 2 — Number Caught Parasites	Total — Number Caught Midges	Total — Number Caught Parasites
May 2–24	0	0	0	0	0	0
May 25–31	1	4	1	9	2	13
June 1–7	13	37	15	49	28	86
June 8–14	7	53	4	34	11	87
June 15–21	0	16	0	11	0	27
June 22–28	0	11	0	5	0	16
†June 29–July 5	0	0	0	0	0	0
July 6–12	0	1	0	8	0	9
TOTAL	21	122	20	116	41	238

In the first week of June, 1939, when adults were in flight, the long shoots of the red pine were still in the "chaffy" stage. Though growing very rapidly at the time, they had made only about half the season's length. On the leader, the needles of the lower short shoots protruded only a few millimetres beyond their sheaths, while those near the top were still crowded and completely enclosed. The fact, that the uppermost short shoots are commonly unaffected by needle blight or late fall browning, is to be explained by their not being readily available for oviposition.

Ovipositing was observed by confining trapped females in a glass jar with a leading shoot of red pine taken June 1st. The midges began at once to adjust themselves. The body was oriented on the sheath parallel to the needles, with the posterior end directed downwards. The insect moved slowly around, probing vigorously with its ovipositor for an aperture between the scales. Having gained a favourable place, the

*Identified by Mr. C. F. W. Muesebeck, United States Department of Agriculture.
†Period of rainy weather and fog.

organ was thrust downwards and the insect came to rest. In its descent, the ovipositor parallels the needles, without penetrating or injuring them. The egg is laid among the innermost scales, sometimes against the needle itself; but the act causes no mark or immediate injury thereto.

In examining a large number of short shoots in June, eggs were occasionally found in unexpected places, as on a twig at the point of attachment of a short shoot, and on the fimbriated edges of the outermost sheath scales. Eggs were also found singly and in clusters stuck to the glass of a flask in which adults had been trapped.

(c) *Rearing Experiments*

(a) *Rearing from the Soil*

In late October, a bulk of top mineral soil was taken from a fall browned Orr Lake plantation. Sifting a sample demonstrated the presence of gall midge larvae therein. A number of containers in which the soil was placed were prepared as follows:

Containers 1 and 2: Wooden bench flats 12″x18″x3″, each containing 200 cubic inches of soil.

Containers 3 - 6: 6″ flower pots, each containing 50 cubic inches of soil.

Containers 7 - 10: 14″ flower pots each containing 250 cubic inches of soil.

The containers were lightly covered with sphagnum, sunk in the soil out of doors and left undisturbed until spring. On May 1st they were brought into the greenhouse, sunk in a sand bench and kept moist. Containers 1-8 were fitted with tight galvanized iron covers in which one inch circular holes had been cut for traps, as already described. Large glass funnels were inverted over the soil of containers 9 and 10, on the stems of which the traps were mounted.

During the period May 27th to June 5th, ten female gall midges were taken. From May 16th to June 10th one hundred and thirty eight chalcid-fly parasites, mostly *Platygaster filicornis* Ashm., and a few *Inostemma* sp. were captured. A record of the traps is given in Table No. 3.

TABLE No. 3

REARINGS FROM SOIL IN CONTAINERS

	Rearing Chamber No.										
	1	2	3	4	5	6	7	8	9	10	Total
No. of Gall Midges taken....							1	1	5	3	10
No. of Chalcid Flies taken...	30	51	3	8	17	7	6	4	2	10	138

(*b*) *Rearing from Infested Shoots*

About 500 cubic inches of native Orr Lake forest soil were sterilized in an autoclave, washed in water, and placed in a large glass vessel. A long shoot of red pine taken October 12th, and known to harbour gall midge larvae was placed on the soil surface. The vessel was covered, and wintered outdoors. It was brought in May 1st, fitted with a trap and wrapped in black paper. A single female gall midge and a number of chalcid fly parasites were taken.

In another experiment, about a bushel of fall browned short shoots were taken from the trees in mid-October and placed in a forty gallon metal drum, which was left in an unheated shed over winter. In early spring a tight top was fitted and traps similar to those already described were arranged. A number of adult midges were taken, the first on May 26th, and the last on June 15th. On opening the drum on June 20th, many dead adults were found, including some which were diagnosed tentatively by Dr. E. P. Felt as *Hyperdiplosis.*

(*c*) *Rearing from Collected Larvae*

Many larvae were collected after they had crawled from infested shoots. They were kept in a box with sphagnum in a refrigerator until November 11th. Five rearing chambers were then prepared as follows: A layer of absorbent cotton was placed in a ½ litre Ehrlenmeyer flask and wetted lightly. In each flask ten larvae were placed on the cotton and covered with an inch of non-absorbent cotton. The flasks were lightly plugged and placed in a dark refrigerator at 40° F. On February 21st, they were placed at 50° F. and on February 27th removed to the greenhouse and kept in the dark at a temperature which fluctuated from 50°–70° F. A few drops of water were added from time to time.

In spite of the low temperature, many of the grubs became mouldy, and some were obviously dead by the end of the year. At that time there was no reaction by any of them to light pricking with a needle, a test which had not failed to induce movement earlier. No cocoons were constructed, but some larvae buried themselves in the cotton and gathered a few fibres about them. Others appressed themselves tightly against the glass.

On March 5th two individuals of *Platygaster filicornis* Ashm. were found in one flask and on March 7th there was one in each of two others. The flasks were watched until April 15th, but there were no more emergences.

From a consideration of the above, the known life history of the red pine gall midge in Ontario may be summarized as follows: The insect oviposits in the short shoots of the host in late spring or early

summer, beginning while the new growth is still in the "chaffy" stage, stage, and continuing, probably, for no great length of time. Coincident and persisting for a longer time is the flight period of chalcid fly parasites. The gall midge oviposits near the base of the innermost scales of a short shoot of the current season and the eggs hatch about the middle of July. By the end of September the larvae are full grown and can be found in characteristic cavities at the very base of the needles. In October or later, the larvae migrate from the short shoots and fall to the ground, where they hibernate and pupate near the top of the mineral soil. The adult emerges from the soil the following spring.

II. The Fungus Pullularia pullulans (de Bary) Berkhout

(a) History and Classification

From the necrotic needle bases of red pine, short shoots suffering from "needle blight", a fungus *Pullularia pullulans* (de Bary) Berkhout may be regularly isolated. Before offering observational and experimental evidence in support of the thesis that this fungus is the essential cause of the typical needle blight condition, it will be appropriate to give here an account of its history and classification, and a report of original cultural and morphological studies.

De Bary (3) gave the name *Dematium pullulans* to a fungus which abstricted from its colourless septate hyphae, large numbers of conidia, which, in turn, budded like yeast cells. In time, spores and hyphae passed to a resting stage, becoming thick walled, rounded and dark coloured; but on transference to a new medium, a resting cell would put forth a germ tube which again budded spores. De Bary did not definitely classify his fungus but suggested that it was probably related to *Fumago* or *Pleospora*. Following de Bary, Loew (32) published a much more extensive account of the fungus and its authorship is often ascribed to de Bary and Loew jointly.

According to the original description, (35) *Dematium* Persoon embraced forms with erect branching conidiophores bearing chains of conidia laterally. *Dematium pullulans* can scarcely be brought within this definition. True, as found in nature on the usual substrata, one would place it in the *Dematiaceae* near *Torula* Pers. or *Hormiscium* Kuntze; but the budding phase obviously belongs in that chaotic group, the so-called *Pseudosaccharomycetes*, along with *Mycoderma* Pers., *Torula* Turpin, *Pseudosaccharomyces* Klocker, etc. An appreciation of these facts led Berkhout (6) to place the fungus in a new genus, *Pullularia*, which had as its primary diagnostic criterion this distinctive budding habit. Similarily, Lagerberg et al. (30) independently instituted *Hormonema* on the same basis. Believing, however, that *Dematium pullulans*

de Bary comprised heterogeneous elements, they dismissed it as invalid for purposes of typification; but they allowed *Dematium pullulans* in Neger's description (33) to stand as typical of their genus. Their species *Hormonema dematioides* was said by them to be closely allied to if not the same as the latter. Robak (38) subsequently made the combination *Hormonema pullulans*. A synonomy may be given, therefore, as follows:

Pullularia pullulans (de Bary) Berkhout, Dissert, Utrecht, 1923.

Dematium pullulans (de Bary, Morph. u. Physiol. Pilze. 1866. Loew, Jahr. Wiss. Bot. 6, 467-477. 1867. Neger, Flora 110, 67-139, 1918.

Hormonema dematioides Lagerberg and Melin, Svenska Skogs Tidsk. 25:2. 1927.

Hormonema pullulans Robak, Nyt. Mag. for Natur. 71. 1932.

The long and contentious argument as to the identity and relationships of this fungus is scarcely indicated by the above discussion. It has been adequately reviewed by Neger (33) and more recently by Hoggan (26), Bennett (5), Lagerberg (30), and Robak (38). The early claims of Laurent, Massee, and others that *Dematium pullulans* was a form of *Cladosporium herbarum* were shown to be false. Others have claimed that it had no identity but was a form of several ascomycetes. Bennett (5) found on wheat straw, associated with *Dematium pullulans*, an ostiolate perithecoid fungus which he called *Anthostomella pullulans*. Plantings made from the ascigerous fructification yielded the mycelium of *Dematium pullulans*, and in time "immature" perithecia were produced in culture. Some of the isolates of *Dematium pullulans* which Bennett secured from nature showed distinct morphological and cultural characters, but he considered that they should all be referred to *Anthostomella pullulans*.

In my own work, of the many cultures secured from red pine, none showed any appreciable differences. I have failed to find any ascigerous fructification, but in the fall and in the spring on overwintered needles non-ostiolate pycnidia developed. Such bodies have not been described in this fungus heretofore. They occurred in the black cushion-like sclerotial masses commonly found at the margin of needle blight lesions, under the scales of the needle sheath. Small hyaline single-celled spores were borne on short sporophores in simple or locular cavities. Although no organized aperature existed, spores were liberated somehow from such fructifications in water.

Professor Lagerberg kindly examined cultures of the fungus secured from red pine at Midhurst, Ontario, and stated that it was identical

with the type treated by him and Dr. Melin under the name *Hormonema dematioides* (31)

(*b*) *Occurence in Nature*

The fungus is widespread in nature, and occurs abundantly in many substrata though chiefly as an epiphyte. Neger (33) found it a common component of sooty mold on the foliage of many trees in Germany. In England, Bennett (5) found it as a saprophyte on decaying vegetable matter, and as a weak parasite on etiolated wheat seedlings. In Sweden, Lagerberg et al. (30) found it on live pine needles, and as an important blue staining fungus in pine timber. Robak (38) isolated it from cold ground wood pulp in chutes, from sludge on the screens, and from stored pulp. He said that it was one of the most active pulp staining organisms. Brooks and Hansford (8) found it as a mold on cold storage meat. Clifferi and Ashford (11) isolated it from lesions on various parts of the human body, but did not consider it pathogenic. In red pine plantations, it occurs chiefly on the accessory foliar parts. It is favoured by wet weather and becomes epidemic when associated with gall midge infestation of the short shoots.

(*c*) *Cultural Characters*

The fungus is easily secured by planting tissue removed from infested needle bases, or fragments of bud or sheath scales, or bract tips, on which it is growing. The agar substratum employed should be very soft to induce sporulation, from which pure cultures are readily established.

A remarkable characteristic of the fungus is its prolific budding of conidia or bud spores (blastospores of the medical mycologists (14) directly from the hyphal cells. (Plate IV, Figs. 4 and 5, Plate VII, Fig. 1). This growth habit is typical of fresh isolations of the fungus from natural substrata when placed on soft agar, and according to Bennett (5) is induced by protein in the culture medium. A young culture is at first rather viscous, dirty white in colour, and consists largely of a mass of budding blastospores with a scant growth of coarse hyaline parent hyphae. In a few days, the culture darkens through the increase of dark mycelial elements, and the gradual suppression of budding. Henceforth the culture remains dark, and grows as a mycelium. Blastospores originate anywhere on the cylindrical wall of the parent cell, but most frequently near a septum. They are attached by an exceedingly fine connection and on release leave a small circular mark which is soon obliterated. (Plate VII, Fig. 1). At first rather elongate, a blastospore becomes more ovate as it matures (Figs. 9-11); such spores freed from the parent cell may themselves bud or again may form a hypha which

after septation begins to sporulate. Various types of dark spores and hyphal elements are produced in ageing cultures, and blastosporic sporulation is then suppressed.

For microscopic study of germination and growth, spores were sprayed on agar films on slides. A series of such preparations was held in a moist sterile culture dish, and slides therefrom were fixed and stained after various intervals of time. Under these conditions the blastospore first swelled considerably, then commenced to elongate but did not produce a true germ tube. (Plate VII, Figs. 1, 2, 3, 4.) A dense margin appeared at the periphery of the cell and the central part became vacuolate. Septation began to show with the first branching of the hypha, by which time the density against the cell wall had disappeared. When several radiating hyphae had been produced, blastosporic sporulation commenced.

In old cultures, various hyphae and spore elements were found. The principal types were (1) branching chains of sheathed dark spore-like cells which were common in old water cultures (Plate VII, Fig. 19); (2) chains of dark spores, many bi-cellular (Fig. 5); (3) irregular chains, comprising waisted bi-cellular elements, and narrowly ovate, asymmetrical cells, joined by narrow connections, grown in water (Fig. 7); (4) fine parallel-walled septate hyphae (Fig. 6); (5) irregular forking chains of waisted bulbous, spore-like cells (Fig. 16). Growth from the cells of old stagnant cultures was induced by transference to fresh media. Thus, emergence of a fine hyaline germ tube from the apex of a terminal hyphae cell was observed (Fig. 17). Again, single bud spores (conidia) were abstricted laterally. These conidia were larger and more broadly oval than the blastospores produced prolifically in vigorous young cultures, and were attached to the parent cell by a broader base (Fig. 18).

Pullularia pullulans isolated from red pine needle blight lesions was grown in culture over a period of years. A series of plates of two percent malt agar was lightly sprayed with a suspension of freshly produced blastospores and immediately placed outdoors in a copper container in freezing weather. (Dec. 12th). After three weeks of unusually cold midwinter weather, the plates were found covered with a scant white mycelium which was without blastospores. After six weeks a few dark hyphae had appeared and blastospores were numerous. A period of warm weather followed, and at the end of seven weeks the cultures were completely black. These plates were allowed to remain outdoors in their container and were inspected and tested for viability periodically. For three years viability was well maintained, as evidenced by ready growth from scrapings of the dried agar. During the fourth year it declined until at the close only one of many transfers grew.

III. Pathogenesis

(*a*) *Postulation of the Theory*

From a consideration of the symptoms, the following theory of the cause of needle blight and late fall browning was postulated. Both maladies originate following ovipositing by a gall midge within the sheath of scales of a short shoot of the current season. This act in itself causes no injury but may lead to infection by the fungus *Pullularia pullulans*, which is commonly present on the sheath scales. If infection takes place, progressive necrosis of the needles within the sheath leads to a weakening and collapse of the tissues. The development of this lesion, coupled with continued growth from the needle bases results in the short shoots bending over in the hooked habit characteristic of needle blight. Should infection not take place (or should it be delayed until growth has ceased and the needle bases have become hard enough to resist crooking), late fall browning at length develops as a result of the injury caused by the larva alone.

(*b*) *Late Fall Browning*

If the assumption is made that the injury at the base of the needles which is demonstrable in all cases of typical late fall browning is the cause of their death, the contention that the disease is due to gall midge infestation rests on proof that a gall midge causes the injury. Ample evidence has been brought forward to establish this claim. The salient points may be summarized as follows:

1. Larvae can always be found before their migration conformably in the basal cavities.
2. Adult gall midges have been reared from these larvae.
3. The gall midges have been observed ovipositing in the short shoots.
4. Eggs and immature larvae have been found in the short shoots.

(*c*) *Needle Blight*

The contention that needle blight is caused by fungus infection following ovipositing by a gall midge is based on deductions from field and laboratory observations, and by experiments which are outlined in the following paragraphs:

I. Inoculation Experiments

Many attempts were made to cause needle blight in red pine by spraying the short shoots with an aqueous suspension of *Pullularia pullulans*. Inoculations were made at various times from early May until late June. Some shoots were left exposed, others were confined in moist chambers. In no case did disease develop following these treatments.

In early June, a series of experimental woundings and inoculations of needles *in situ* was made. At that time the long shoots had attained about half their growth in length for the year and their needles, which were about an inch and a half long (except near the tip where they were shorter), protruded a few millimetres beyond the sheath. The tree selected for inoculation was in a locality which had been free from needle blight and late fall browning. Four pairs of long shoots were chosen and twenty-five short shoots on one member of each pair received treatment A, while the same number on the other member received treatment B. The treatments were as follows:

Treatment A A 30 gauge hypodermic needle was inserted through the sheath of scales so as to pierce one leaf and enter the other at a point near their common base, and a few drops of a concentrated aqueous suspension of spores of *Pullularia pullulans* were injected.

Treatment B The same as treatment A, using water only.

The shoots were re-examined in late September. In no case had typical needle blight been caused but three types of response were noted as follows:

1. Healing of the wounds, with more or less normal growth.
2. Stunting of the needles.
3. Stunting and death of the needles with basal necrosis and invasion by *Pullularia pullulans*.

Some needles under both treatments healed their wounds and continued more or less normal growth, so that the wounds were carried outwards and were found about an inch and a half from the distal ends. Many of these needles were slightly twisted or bent near the wounds.

Under treatment B, twenty-two short shoots had one or both needles markedly stunted. Many of these had grown little if any since treatment. In six of the short shoots one or both needles were dead and had been invaded by *Pullularia pullulans*.

Under treatment A, one or both needles in twenty short shoots had died. All of these and several more were stunted. None of the short shoots was hooked as in typical needle blight, but all the dead needles were infected basally by *Pullularia pullulans*.

Data from these experiments are given in Table No. 4. It may be assumed that the mortality difference under the two treatments was significant, since the probability that this was so is greater than twenty to one.*

*(Value of odds derived from table of "t" in R. A. Fisher's "Statistical Methods for Research Workers.")

From these experiments it may be concluded that *Pullularia pullulans*, even though present in great abundance on the short shoots, does not infect the needle bases under ordinary circumstances. On the other hand, the fungus is pathogenic in red pine short shoots under appropriate circumstances. Exactly what these circumstances are has not been ascertained. Direct proof of a causal relationship between the gall midge larva and needle blight is lacking but the evidence pointing in that direction is very strong. The young larva induces a slight hyper-

TABLE No. 4

EFFECT OF INOCULATION TREATMENTS

Treatment	Experimental Pairs of Shoots	1	2	3	4
A	Short shoot mortality	5	5	7	3
B	" " "	1	0	3	2

trophy in the leaf tissue where contact is made with it, and apparently causes an exudation of juice which is doubtless ingested. As the larva grows, the pocket or cavity formed, moist as it is with nutritive juice derived from the injured host and the insect itself, would seem to provide an ideal infection court for *Pullularia pullulans*. In this connection, the stimulation which protein exerts on the budding habit of the fungus noted by Bennett (5) may have significance. The examination of needle blight lesions, which is difficult on account of the nature of the material, has not disclosed any trace of a larva. It is believed that in typical blight the larva, while still quite small, is destroyed in the development of the lesion. This brings to mind interesting speculations on the inter-relationships between epidemics of midges and *Pullularia pullulans*. That the fungus waxes and wanes with needle blight epidemics is a matter of observation. Can it be that it has a significance in both the cause and control of blight disease?

(*d*) *Summary of Evidence*

The evidence supporting the stated theory of the cause of needle blight may be summarized as follows:

Proposition 1: That the fungus *Pullularia pullulans* infects young needle bases within the sheath of scales, causing necrosis and typical needle blight symptoms.*

(a) *Pullularia pullulans* is ubiquitous wherever epidemics of needle blight occur.

(b) It is constantly associated with needle blight lesions, as demonstrated by visual examination and recovery in culture.

*The assumption is made that the "typical symptoms" result from the lesion.

(c) It is intimately associated with such lesions as evidenced by the pathological anatomy.
(d) It has been shown experimentally to possess pathogenic potentialities in wounded red pine needle bases.

Proposition 2: That the occurrence of infection is dependent on infestation of the short shoot by a gall midge larva.

(a) Needle blight does not occur, under ordinary circumstances, even if *Pullularia pullulans* is present on the sheath scales.
(b) Infection did not follow the inoculation of short shoots by spraying with spores of *Pullularia pullulans*.
(c) Infection followed the inoculation of wounded needles.
(d) Needle blight has been associated with known gall midge infestations.
    1. Over a period of years, needle blight has occurred only where gall midges were known to be prevalent in red pine.
    2. Needle blight followed in August an infestation demonstrated in June by the discovery of eggs in short shoots.
(e) In its epidemic characteristics, needle blight resembles late fall browning, which is known to be caused by a gall midge.
(f) There is a continuous variation in the symptoms of needle blight from "typical" to an approach to those of late fall browning.
(g) The gall midge larva infesting short shoots is known to cause an injury which would seem to provide a favourable infection court.

6. CONTROL

A few references to the control of gall midges by direct means have been made in the literature. In the case of young Scots pine infested with *Thecodiplosis brachyntera*, Smólak (39) recommended shaking the withered short shoots from the trees and burning them. For gall midges in Monterey pine, Burke (9) advised spraying with nicotine oil emulsion.

It is probable that the state of the weather at the time of emergence of adults and during the flight period is of critical importance. In a biological study, Barnes (2) said that the weather might be of more importance in the control of gull midges than their natural enemies. Wallengren found that successful emergence of wheat blossom midges depended on favourable weather. Hard rains caused the death of many adults on the ground.

A few predators of gall midges have been reported. Snow and Mills (4) found that a mite, *Pediculoides ventricosus* New. fed on the eggs, larvae and pupae of the Monterey pine midge, and that lady beetles destroyed the larvae and pupae. The ruby-crowned kinglet, too, was

said to feed on ovipositing females. I have already reported in this paper that, in infested red pine plantations, spider webs were unusually abundant, and were effective in catching midges.

Among the natural enemies of gall midges, chalcid fly parasites of the larvae are undoubtedly the most important. A number have been reported from conifer infesting midges. According to Tubeuf (44), Zimmer and Schwägrichen reared one from the larvae of *Thecodiplosis brachyntera* which they named *Ceraphron brachynteri*. Snow and Mills (40) found *Polygonatus diplosidis* Ashm. on *Diplosis pini-radiatae*. Stebbing (41) recorded that a species of *Trigonomerus* was found on a *Cecidomyiid* infesting *Pinus longifolia* in India. Williams (46) said that *Cecidomyia resinicoloides*, a species which he described from the Monterey pine, was singularly free of parasites, but that in two instances a chalcid fly, apparently *Syntasis diplosidis*, was reared from larvae. Felt and Bromley (24) reared several unidentified parasites from *Itonida pinifoliae*.

Over a period of years, parasites have exercised a powerful controlling effect on needle blight and late fall browning at Midhurst and Orr Lake. It is evident that repeated defoliation to the extent of seventy-five percent or more of the current season's foliage, as has sometimes been suffered, could not be supported for long. Yet, during the eight years that the midge is known to have been present at Midhurst, no mortality has been suffered in the plantations there on account of it. This is believed to be due to effective parasitism.

The history of individual infestations has been that such have reached their year of maximum intensity before being detected. It is probable that a number of years of low but rapidly increasing intensity has actually passed in the development of any epiphytotic. In some instances, radial spread of disease has occurred, which could be accounted for by wind dispersal of adult midges. Dense local infestations might thus occur in previously clean areas. The season following that of maximum intensity of infestation has always been marked by an important decline; and I cannot recall an instance where "late fall browning" persisted noticeably for more than three years in one spot.

At Midhurst and Orr Lake, two chalcid flies have been obtained namely *Platygaster filicornis* Ashm. and an *Inostemma* species tentatively diagnosed as *Inostemma lintneri*. I am indebted to Mr. C. F. W. Muesebeck of the United States Department of Agriculture for these diagnoses. Of the two, *P. filicornis* is indubitably a parasite of the red pine gall midge, as it was reared from authentic material. The *Inostemma* sp. was reared from a bulk of needles in a drum container. As these needles

came from fall browned trees, it is highly probable that the *Inostemma* sp. is also a parasite of the red pine gall midge.

One or both of these chalcids have been observed in the field. *Platygaster filicornis*, apparently the commoner, has frequently been seen in flight, and has been caught on emerging from the ground. The flight period begins about the time of that of the gall midges, but apparently persists a good deal longer, as might be expected (see Table No. 2). Whether ovipositing is in the eggs or larvae or both was not discovered with certainty, but it was going on in the field in early June when eggs were found in the short shoots. In 1939 some parasites were trapped in flight until mid-July.

The following data from an epidemic of late fall browning which persisted for several years in a plantation set out in 1928, indicate the course of the disease and the effect of parasitism:

Year	Estimated Seasonal Foliage Loss	Remarks
1937	Very little	The disease was not detected.
1938	75 percent	Plantation appeared in late fall as if burned.
1939	30 percent	Parasites were abundant in the field in the spring. Conspicuous foliage loss. Parasites were reared in abundance from material collected in the fall of 1939.
1940	Less than 2 percent	In the spring parasites were very abundant in the field. The foliage loss was not noticeable.

7. SUMMARY

This paper deals with needle blight and late fall browning, diseases of the foliage of red pine (*Pinus resinosa* Ait.) in forest plantations. The maladies may cause very severe defoliation which could not be tolerated for many seasons. They are therefore potentially dangerous but where observed in Ontario have come under natural control through parasitism before mortality has been suffered. A gall midge (*Cecidomyiid*) is the initiating agent of both. Needle blight is caused by infection of the bases of the needles of midge-infested short shoots by

the fungus *Pullularia pullulans* (de Bary) Berkhout. Late fall browning is the result of injury caused by the larva of the gall midge alone. The pathological symptoms are described, and the history of these and similar maladies in America and Europe is reviewed. A description and life history of the red pine gall midge is given. The adult midge emerges from the soil in the spring or early summer. Eggs are laid inside the sheath of scales, at the base of the needles of the host. In the fall, larvae emerge and drop to the ground where they hibernate at a depth of an inch or less, in the mineral soil. Chalcid flies parasitize the larvae of the gall midge, and are of great importance in control. Of two species found, *Platygaster filicornis* Ashm. was the more abundant.

ACKNOWLEDGMENT

The writer acknowledges assistance received from the following, to whom he extends his thanks: Mr. M. A. Adamson, Superintendent of the Forest Station, Midhurst, Ontario, who first drew my attention to needle blight of red pine, and who was associated with me in the first studies of it; Professor E. M. Walker, University of Toronto, and Dr. E. P. Felt, Bartlett Tree Research Laboratories, who made tentative diagnoses of gall midge specimens; Mr. C. F. W. Muesebeck, United States Department of Agriculture, who diagnosed the parasites, Dr. F. P. Ide, University of Toronto, for advice on collecting and rearing gall midges; Miss M. B. Givens, University of Toronto, for cutting a series of sections, represented in Figs. 14-16, Plate 3, herewith; Professor Torsten Lagerberg, Stockholm, for a critical examination of cultures of *Pullularia pullulans;* Dr. William C. Davis, United States Department of Agriculture, for specimens of "needle droop"; Messrs. Chas. Day and J. Lea of the Ontario Forestry Branch, for help in field experiments.

This investigation was sponsored by the Department of Lands and Forests, Province of Ontario, Canada. Acknowledgment is made of laboratory facilities provided by Dr. A. L. MacNabb, Director of Laboratories, Department of Health.

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EXPLANATION OF PLATES

PLATE IV

FIG. 1.—Needle blight of red pine, Midhurst, Ont., Aug. 5th.

FIG. 2.—Young plantation of red pine affected by needle blight, Midhurst, Ont., Aug. 20th.

FIG. 3.—Sheath scale from short shoot of red pine infected with ***Pullularia pullulans*** (X-10).

FIG. 4.—Single spore colonies of ***Pullularia pullulans*** on agar (X-50).

FIG. 5.—Tip of sporulating hypha of ***Pullularia pullulans*** from one of the colonies shown in Fig. 4. Some of the blastospores are still attached, others have been liberated (X-400).

FIG. 6.—Sheathed spore chain and gemmae of ***Pullularia pullulans*** from water culture. (X-500).

PLATE V

FIG. 7.—Late fall browning in red pine; specimen taken at Midhurst, Oct. 20th.

FIG. 8.—Short shoot with scales dissected away to show the basal cavity, formerly occupied by the larva of a gall midge. (X-4).

FIG. 9.—Larvae of the red pine gall midge ***in situ***. Two are shown. As a rule only one is found in each short shoot. (X-4).

FIG. 10.—Short shoot of red pine suffering from needle blight, with characteristic crook. (X-7).

FIG. 11.—Larva of the red pine gall midge. Ventral aspect (X-10).

FIG. 12.—Culture of ***Pullularia pullulans*** on malt agar (X-½).

FIG. 13.—Needles withdrawn from the sheath of a blighted short shoot which overwintered on the ground. Note the erumpent sclerotia and anostiolate pycnidia of ***Pullularia pullulans*** at the margin of the lesion (X-15).

PLATE VI

FIG. 14-16.—Transverse sections through the base of an infested short shoot of the red pine showing the red pine gall midge larva in situ. This short shoot displayed no field symptoms of late fall browning at the time of collection but shortly thereafter the tree from which it came suddenly browned.

FIG. 14.—Section from the proximal part, showing the anterior end of the larva in the axil of a sheath scale.

FIG. 15.—Section from the median part showing the geminate needles, and a median section of the gall midge larva in which the gut is conspicuous.

FIG. 16.—Section from the distal part showing the needle pair and the anterior end of the gall midge larva. The tissue systems of the leaf, other than the vascular and epidermal are not well differentiated, and are clearly traumatic. (X-32).

FIG. 17. Red pine gall midge, adult female, reared from larva collected from fall browned short shoot (X-20).

FIG. 18.—*Platygaster filicornis* Ashm. adult female. Reared from larva of the red pine gall midge (X-20).

PLATE VII—*Pullularia pullulans* (de Bary) Berkhout

FIG. 1.—Blastosporic sporulation on agar film (X-1500).

FIGS. 2-4.—Germination of blastospores. 17 hrs. on agar film at 27° C. (X-1000).

FIG. 5.—Bicellular and unicellular dark spore chain, from old culture (X-850).

FIG. 6.—Fine hyaline parallel hypha. (X-850).

FIG. 7.—Spore chain from 48 hr. water culture (X-850).

FIG. 8.—Spore masses from tracheid elements of red pine needle sheath scale (X-850).

FIGS. 9-11.—Blastospores in water (X-1000).

FIGS. 12-14.—The same, after 24 hrs. (X-1000).

FIG. 15.—Sheathed tri-septate dark spore in water culture of blastospores, after one week (X-1000).

FIG. 16.—Gemmae in old agar culture (X-850).

FIG. 17.—Terminal bicellular spore, germinating by means of germ tube on transference to new medium (X-850).

FIG. 18.—Old hyphal element germinating by means of bud spores on transference to new medium (X-850).

FIG. 19.—Sheathed chain of dark spores grown in water (X-850).

FIG. 20.—Dark hyphae in tracheid elements of red pine needle sheath scale (X-850).


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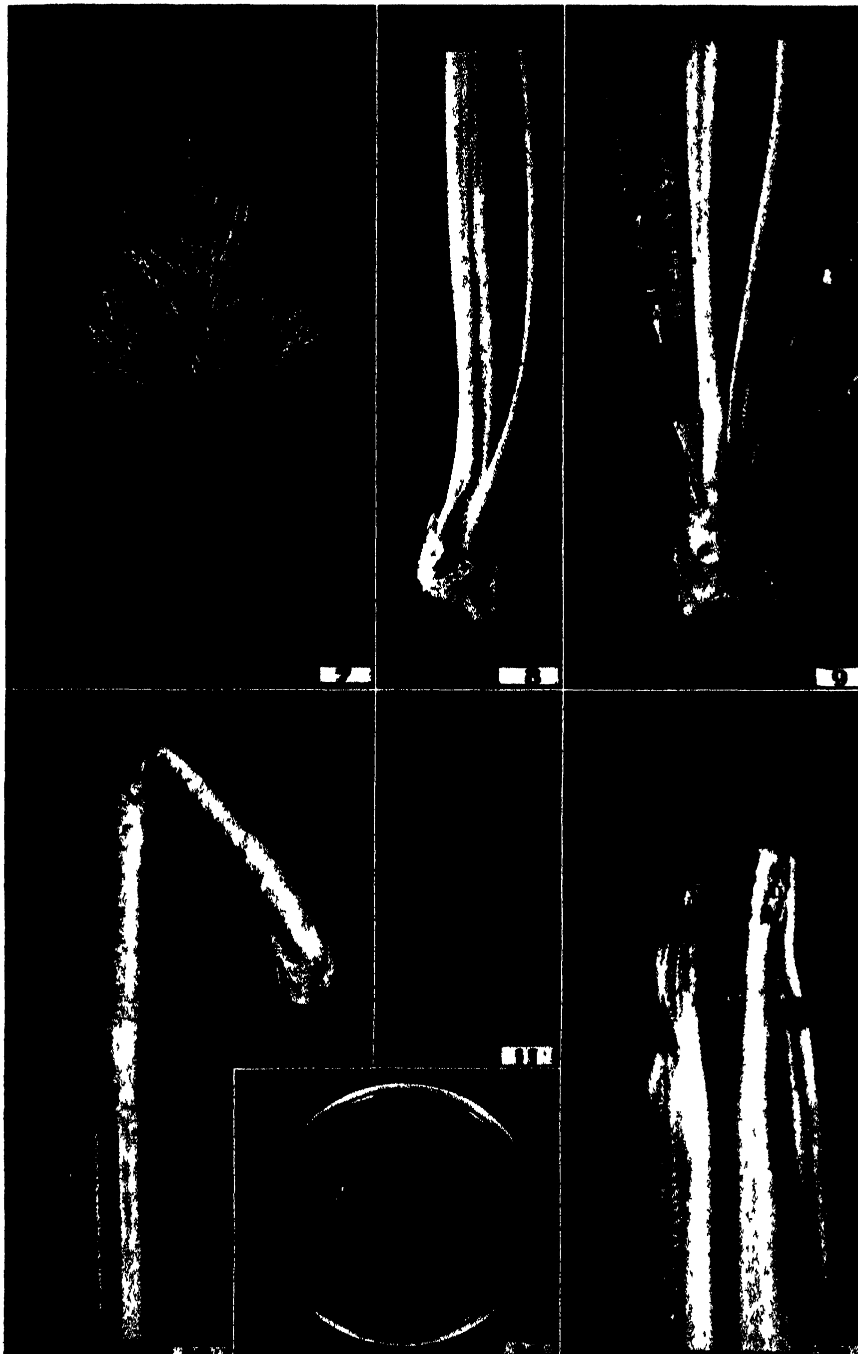

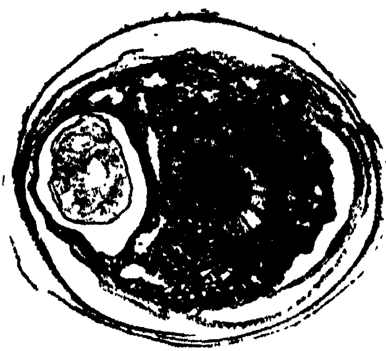

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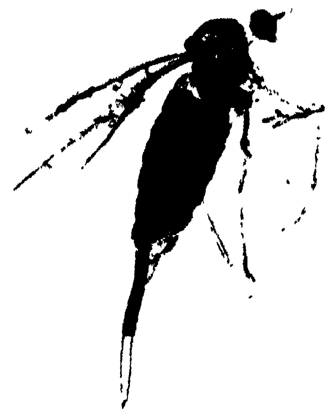

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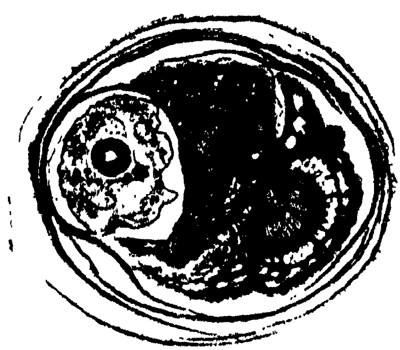

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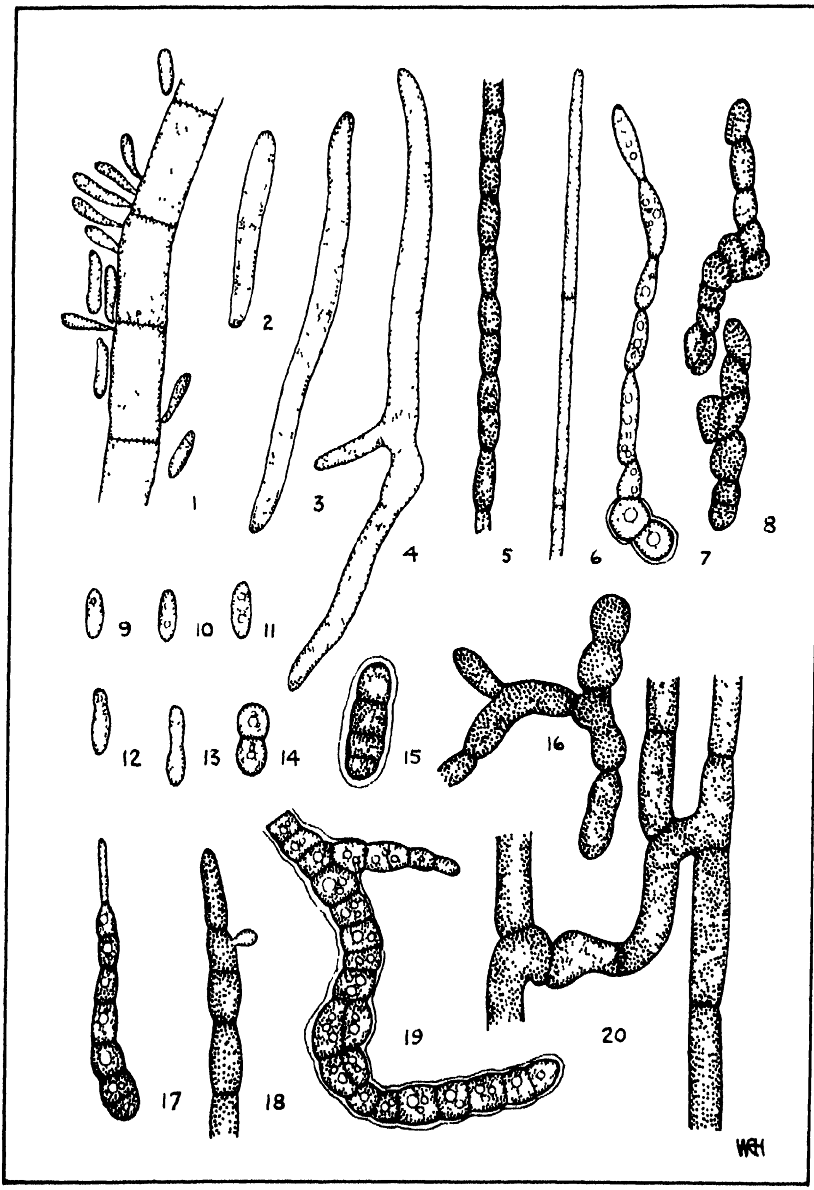
HADDOW: NEEDLE BLIGHT AND LATE FALL BROWNING OF RED PINE



HADDOW NEEDLE BLIGHT AND LATE FALL BROWNING OF RED PINE

LARVAL STAGES OF *CRAGO SEPTEMSPINOSUS* SAY

By Alfreda Berkeley Needler
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ABSTRACT

The paper describes the first stage larva of *Crago septemspinosus* hatched in the laboratory and later stages obtained from plankton collections. The appearance and development of the larvae of *C. septemspinosus* correspond very closely with those of the European species *C. vulgaris.*

So far no larvae of Canadian Cragonidae have been described although the larvae of most of the western European species are known. Around all the shores of Prince Edward Island *Crago septemspinosus* Say is very common. Thus it seemed worth while to describe the larvae of this form and the writer wishes to thank the Fisheries Research Board of Canada for providing facilities for the work. Material was collected near the Prince Edward Island Biological Station on Malpeque Bay.

It should be noted that the nomenclature used by Miss Rathbun (1929) has been followed in referring to the genus *Crago* and the family Cragonidae instead of the more usual *Crangon* and Crangonidae.

Hatching of eggs of *Crago septemspinosus* occurs during the late spring and early summer from mid-June through July. During July all the larval stages may be obtained in plankton tows taken along the shores of the estuaries about a metre below the surface. In 1939 larvae of this species were hatched from eggs in the laboratory but were not reared. Later stages were collected from the plankton and the author is reasonably sure that a complete series has been obtained.

In the accompanying illustrations those of complete larvae are all drawn to the same scale so that they are comparable. Similarly the illustrations of appendages are all to the same scale, although, naturally, a different one from that used for the entire animals.

Descriptions

First Stage (Fig. 1, A-J).

In general the larva is very transparent and colourless, with a slight pink tinge in the antennae and abdomen. There are a few small black chromatophores on the antennae and maxillipeds. They are also down the ventral surface of the abdomen, one on each of the first three segments, three on the fourth and three on the telson.

The larva is 1.9 mm. from the tip of the rostrum to the tip of the telson. The carapace has no dorsal or supra-orbital spines but it has three or four small lateral denticulations. The *eyes* are sessile. The *rostrum* is slender, without denticles, projecting slightly downwards and

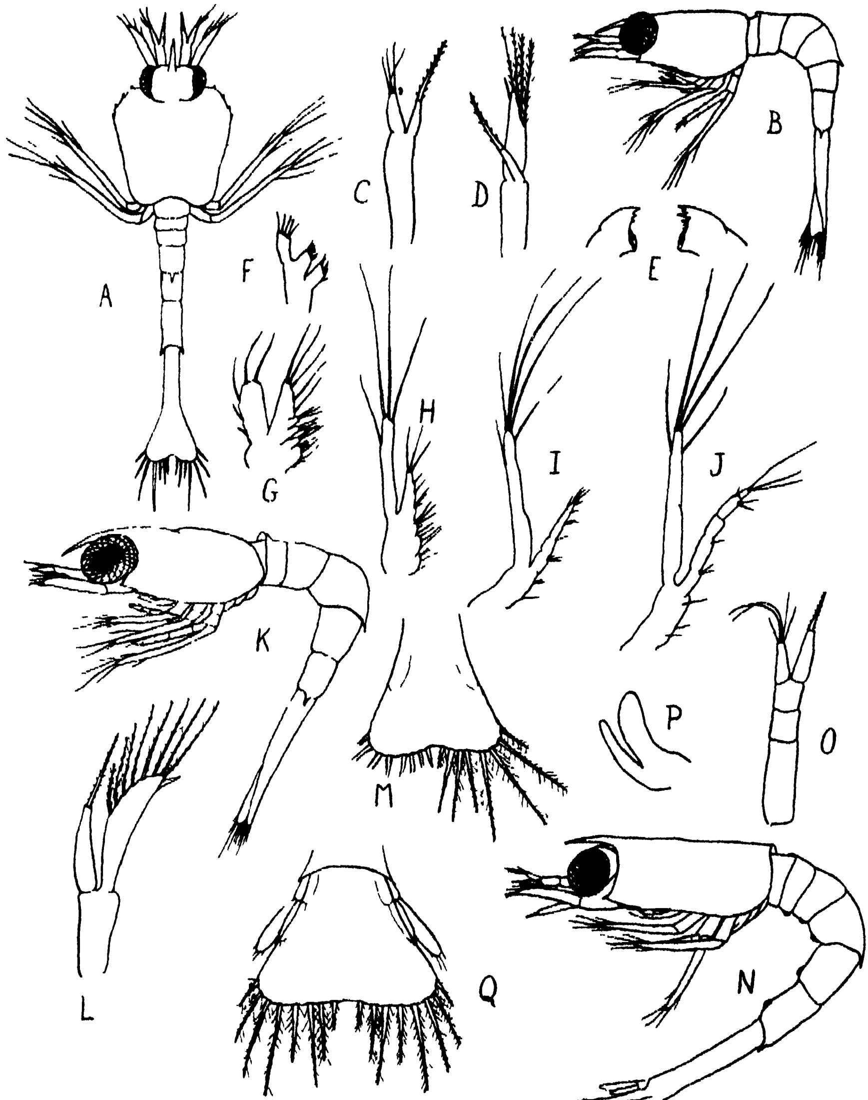

FIGURE 1. *Crago septemspinosus*, first, second and third stage larvae. A, first stage larva, dorsal view; B, same, lateral view; C, same, antennule; D, same, antenna; E, same, mandibles; F, G, same, first and second maxillae respectively; H, I, J, same, first, second and third maxillipeds respectively; K, second stage larva, lateral view; L, same, antenna; M, same, telson; N, third stage larva, lateral view; O, same, antennule; P, same, first pereiopod; Q, same, tail fan.

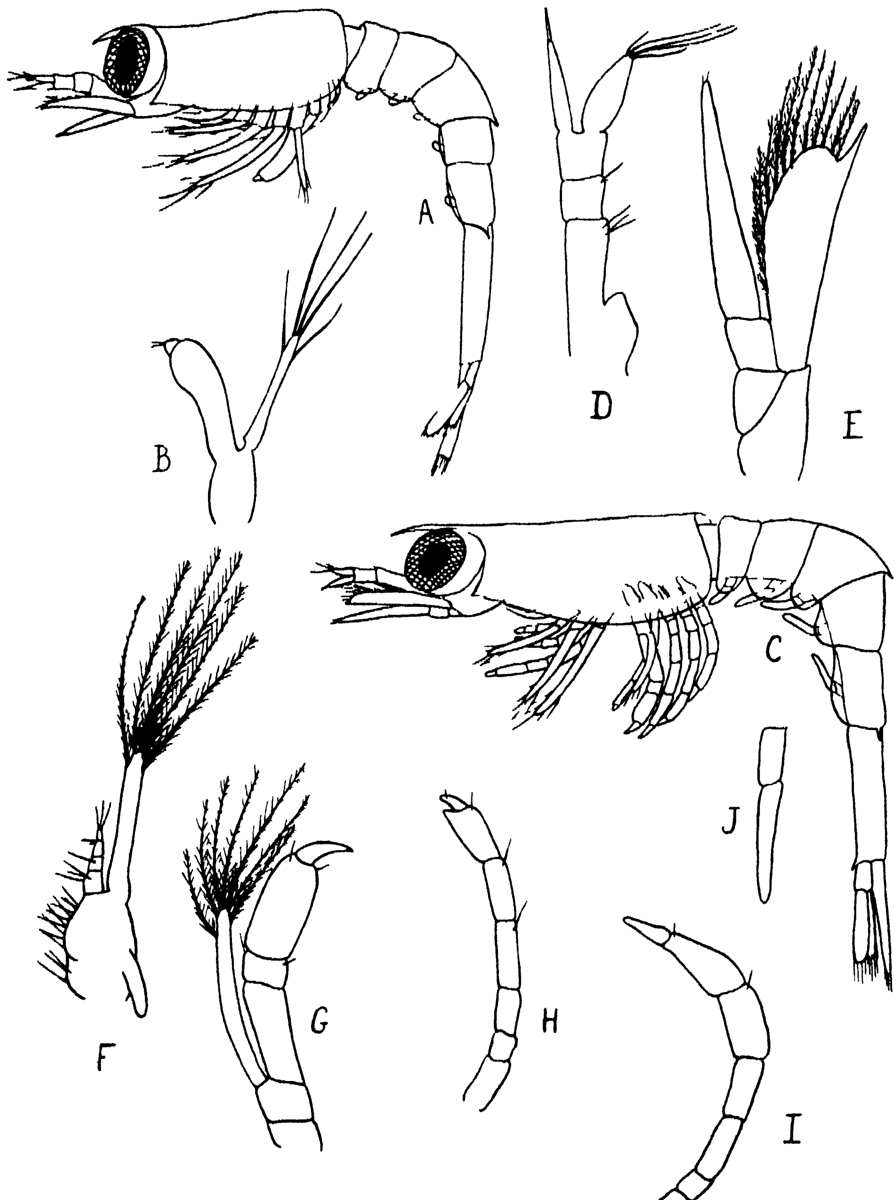

FIGURE 2 *Crago septemspinosus*, fourth and fifth stage larvae A, fourth stage larva, lateral view, B, same, first pereiopod, C, fifth stage larva, lateral view D, same, antennule, E, same, antenna, F, same, first maxilliped, G, same, first pereiopod, H, same second pereiopod, I, same, third pereiopod, J, same, third pleopod

reaching a little past the base of the antennule. The abdomen has a median dorsal spine on the third segment and two lateral spines on the fifth segment. The *telson*, fused with the sixth segment, bears seven pairs of setae which are so delicately plumose that only the central shaft is visible under ordinary magnification. It is slightly indented at the end.

The *antennule* (fig. 1, C) has a tubular unjointed base bearing a small conical segment tipped with four simple setae and a narrower segment tipped by one thick, slightly plumose spine. The *antenna* (fig. 1, D) has an unjointed base. The scale is unjointed and bears four plumose setae and one simple seta. The flagellum is represented by a small joint bearing a long, stout plumose spine.

The *mandibles* (fig. 1, E) have no palps. The incisor process of the right mandible bears two sharp and one blunt denticle and there are three small teeth between this and the molar process. The incisor process of the left mandible is pointed and there are two small teeth between it and the molar process. The coxopodite of the *first maxilla* (fig. 1, F) has one simple and five delicately plumose setae. The basipodite has six or seven short stout spines and the endopodite has five delicately plumose setae. The exopodite of the *second maxilla* (fig. 1, G) bears five delicately plumose setae. The lobes representing coxopodite, basipodite and endopodite are fringed with delicately plumose setae.

The *first maxilliped* (fig. 1, H) is more pediform than the maxillae. The endopodite is unsegmented and bears seven or eight simple setae. The exopodite is about twice as long as the endopodite and bears four sparsely plumose setae. The base is fringed with simple and plumose setae. The *second maxilliped* (fig. 1, I) is larger than the first but similar. There are no joints in the endopodite but five divisions are indicated. The *third maxilliped* (fig. 1, J) has a definitely pediform endopodite with five joints.

There are no pereiopods or pleopods.

Second Stage (Fig. 1, K-M).

The larva is about 2.2 mm. long. The *eyes* are stalked but still set close to the head. The *telson* (fig. 1, M) bears eight pairs of plumose setae and uropods may be seen through the cuticle.

The scale of the *antenna* (fig. 1, L) is more adult in shape, bearing eight or nine plumose setae and one short, stout spine. The basal part of the flagellum is still unjointed but much larger and thicker. There is no great change in *maxillae* or *maxillipeds*. A slight thickening at the base of the exopodite of the second maxilla shows where the proximal expansion will come later. The endopodites of all three maxillipeds are now jointed.

Buds of three pairs of *pereiopods* are present but there are still no pleopods.

Third Stage (Fig. 1, N-Q).

The larva is about 3 mm. long. Epimeral plates are just beginning on the abdomen. The *antennule* (fig. 1, O) has a three-jointed base but the rami have not changed much. In both *second* and *third maxillipeds* the endopodites are larger in proportion to the exopodites.

The *first pereiopod* (fig. 1, P) is an unjointed biramous appendage. The two rami are simple curved bars, one (the endopodite) larger than the other. The remaining four *pereiopods* are similar to the first but uniramous. Many specimens have minute swellings on the abdominal segments where the pleopods will develop.

The *tail fan* (fig. 1, Q) is distinct from the sixth segment. The *uropods* are free and bear a few simple setae. The *telson* is triangular, flatter at the end and still bearing eight pairs of stout plumose setae.

Fourth Stage (Fig. 2, A and B).

The larva is about 3.5 mm. long. The lateral denticulations on the carapace are now very small. Epimeral plates are quite distinct on the first five abdominal segments.

The antennae, mouth parts and maxillipeds have hardly changed except that the endopodite of the *third maxilliped* is about the same length as the exopodite.

The *first pereiopod* (fig. 2, B) has an exopodite tipped with five setae and an endopodite consisting of a long club-shaped portion with a small joint at the end. The remaining *pereiopods* are all simple curved bars without segments or exopodites. The second pereiopod is much smaller than the others. The *pleopods* are distinct but simple buds.

In the tail fan the *uropods* are better developed and well fringed with setae but the *telson* shows little change. There is no anal spine.

Fifth Stage (Fig. 2, C-J).

The larva is about 3.8 mm. long. Although not much bigger than the fourth stage it is so much better developed that it is quite distinct. The *rostrum* is somewhat straighter than in earlier stages. The lateral denticulations of the carapace are very faint or absent.

The *antennule* (fig. 2, D) has a three jointed stem somewhat expanded at the base in the manner of the adult but the rami are essentially little changed from the first stage. In the *antenna* (fig. 2, E) the base and scale are almost adult in shape but the flagellum is represented by a long rod with a short joint (the peduncle) at its base.

The *mouth parts* and *maxillipeds* are little changed but the first *maxilliped* (fig. 2, F) has the epipodite represented by a flat curved bar.

All the *pereiopods* are well developed and a gill has appeared at the base of each. The *first pereiopod* (fig. 2, G) has a stout endopodite of four joints, the fourth joint sharp but not bent over to form a claw. The *second pereiopod* (fig. 2, H) is still more slender than the others and has the propodal joint slightly extended to form the beginning of a claw. The *third pereiopod* (fig. 2, I) is fully segmented and pediform. The *fourth* and *fifth pereiopods* resemble the third.

The *pleopods* (fig. 2, J) are distinctly jointed but are still uniramous and have no setae.

An *anal spine* is present at the base of the tail fan. The *telson* is definitely narrower at the tip but still essentially larval in character.

Sixth Stage (post-larval).

This is the first post-larval or bottom stage and is strikingly different from the fifth larval stage. It is not much larger, being about 4 mm. or 4.2 mm. long, but is superficially just like the parent. The body is flattened dorso-ventrally instead of laterally. There is a median spine on the carapace and the anal spine is still present but the spines on the third and fifth abdominal segments have gone. The *rostrum* is much shorter though not as short as in the adult.

The *antennule* has an inner ramus with three joints and an outer ramus with two rather indistinct joints but the whole appendage still looks immature. Evidently this appendage develops slowly. In a specimen 9 mm. long the inner ramus only had six joints and the outer five while the shape of both, although longer, still suggested the larval. The *antenna* has a flagellum almost as long as the carapace with about twelve joints. The scale is little changed.

The *mandibles* and *maxillae* are essentially adult in shape. The *first maxilliped* still suggests the larval form. The exopodite is longer, whip-like and bent but unjointed. The endopodite and base are much as in the fifth stage. The epipodite is bilobed. The *second maxilliped* is superficially adult but with an unjointed exopodite. The bud of an epipodite is present but no gill. The third maxilliped is also superficially adult. The exopodite is small, bent and whip-like but unjointed. There is a small epipodite.

The *pereiopods* are all completely adult in shape. The first has lost its exopodite. The *pleopods* are quite adult in shape and well fringed with setae but are still almost uniramous. The inner ramus of each is represented by a minute bud bearing one seta.

The *telson* is much narrower at the tip than in the last stage but not as narrow as in the adult. It has two pairs of long stout setae at the tip and three pairs of setae up the sides, one pair quite near the tip.

There is no central stout terminal spine as in the adult and there are no fringing fine setae.

DISCUSSION

In 1890 Sars described the larvae of *Crago* (*Crangon*) *vulgaris* and *C. allmanni*. The former was treated particularly thoroughly. Since then several authors (R. Gurney 1903, 1923; M. V. Lebour 1931; G. E. Webb 1921; H. C. Williamson 1901) have checked his work with larvae of these species obtained by them and have compared these larvae with those of closely related genera.

There seems to be an extraordinarily close similarity between the larvae of *Crago septemspinosus* and *Crago vulgaris*. Superficially the first stages would differ considerably when alive as the Canadian form is transparent and almost colourless while the colour of *C. vulgaris* (Lebour 1931) is "yellow and brown, very dense". But these first stages are about the same size, have similar arrangements of spines and the appendages only differ in small details. *C. septemspinosus* is in some ways slightly slower in its development than *C. vulgaris* as described by Sars, 1890. The antennae, first maxillae, and maxillipeds are about the same stage of development in the second stage of *C. septemspinosus* and the first stage of *C. vulgaris*. The first stage of *C. vulgaris* has the bud of one pereiopod while the first stage of *C. septemspinosus* has none. Otherwise the two first stages are remarkably alike.

In later development *C. vulgaris* grows faster than *C. septemspinosus*, the former being 4.7 mm. to 6.5 mm. long in the fifth stage (Lebour 1931) and the latter less than 4 mm. long at the same stage. Also the anal spine appears at the fourth stage in *C. vulgaris* and not until the fifth in *C. septemspinosus*. But the only essential difference between the fifth stage of *C. septemspinosus* and the fifth stage of *C. vulgaris* is that the flagellum of the antenna is unjointed in the former and jointed in the latter.

Miss Lebour (1931) has listed the general characters of the Cragonidae (Crangonidae). The only way in which the larvae of *Crago septemspinosus* differ from these is in the anal spine being developed at the fifth instead of the fourth stage.

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LIST OF THE ODONATA OF ONTARIO WITH DISTRIBUTIONAL AND SEASONAL DATA

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Although a number of papers giving distributional data on the Odonata of Ontario have appeared since the publication of the writer's first list (Walker '06b), these have been concerned with particular regions or localities and not with the Province as a whole. Meanwhile unpublished records have accumulated to such an extent as to warrant their publication in a single paper embodying all the available data for the study of the distribution of this group in Ontario. The data, however, are still very incomplete, only a few localities having been well explored, and there are still many large areas, even in the settled parts of the Province, in which no collecting has yet been done.

The Province of Ontario extends from Pelee Island, Lake Erie (Lat. 41° 50′), northward through a distance of about a thousand miles to Hudson Bay, on the Manitoba border (Lat. 57°). It is therefore not surprising that a wide range of climatic differences should exist in Ontario with correspondingly great differences in the flora and fauna. At the southern border along Lake Erie these are similar to the flora and fauna of northern Ohio and Indiana, while, approaching the coast of Hudson Bay, they are comparable to those of Labrador, the climate being subarctic or even arctic on the immediate coast. In terms of Merriam's faunal regions, there is a narrow strip of the Carolinian zone in the extreme south and of Arctic in the extreme north, while between these extremes there is the entire width of the Transition, Canadian and Hudsonian zones.

The Province is usually divided into Old Ontario and New or Northern Ontario, the dividing line being taken about the latitude of North Bay, Lake Nipissing. Since the two areas thus defined are very unequal we prefer to follow the plan proposed by Snyder ('38), who divides the Province into four sections (Southern, Central, Western and Northern Ontario), as shown in map 1.*

In terms of Merriam's zones, Southern Ontario, as here defined, corresponds approximately to that portion of the Province which lies within the Austral Region.† The narrow strip along Lake Erie, labelled "Extreme Southern Ontario", belongs to the Carolinian or eastern

*For the use of maps 1 and 2 we are indebted to Professor J. R. Dymond, Director of the Royal Ontario Museum of Zoology.

†For map of Merriam's zones in Ontario, as followed here, see Snyder ('38a).

division of the Upper Austral, while most of the remaining territory lies within the Alleghanian or eastern division of the Transition zone. As one travels northward, the boreal fauna is increasingly noticeable, becoming prevalent in the northern parts of the Parry Sound and Muskoka Districts, Algonquin Park and Renfrew County and, when Central Ontario is reached, one may be said to have definitely entered the Canadian or southernmost zone of the Boreal Region. Both Central and Western Ontario lie within this zone, although west of Lake Superior, particularly in the Rainy River District, there is a greater infusion of southern or Transitional species than at the same latitude in the east (Snyder '38b).

In the present paper no attempt is made to analyze the factors which control the distribution of species. For this purpose our data are still insufficient and much more should be known of the life histories and ecological relations of the various species. Our object is merely to present a list of the Odonata that have been found in Ontario, lists of the localities where each species has been taken, brief notes on the habitats of each species and its season of flight, and a general summary of the fauna of each division of the Province.

We are greatly indebted to all those who have assisted in the collection of specimens and without whose aid these records would be far less complete than they are. Special mention should be made of the following friends and colleagues for the substantial aid which they have given: Dr. C. E. Atwood, Professor J. R. Dymond, Dr. Norma Ford, Mr. T. N. Freeman, Dr. C. S. Hanes, Dr. J. L. Hart, Mr. C. E. Hope, Dr. A. G. Huntsman, Dr. F. P. Ide, Mr. T. B. Kurata, Mr. W. Le Ray, Mr. E. B. S. Logier, Dr. R. B. Miller, Mr. G. M. Neal, Mr. J. G. Oughton, Mr. E. S. Pentland, Dr. W. E. Ricker and Mr. R. V. Whelan.

SOUTHERN ONTARIO

Southern Ontario is divided geologically into two main regions, the Pre-Cambrian Shield to the north and the region underlain by sedimentary rocks to the south. An irregular broken line extending eastward from Sturgeon Bay, at the southeastern extremity of Georgian Bay, to the headwaters of the St. Lawrence River marks the southern boundary of the Pre-Cambrian shield, and another irregular line from the vicinity of Brockville northward to the Ottawa River forms the eastern boundary. The region underlain by sedimentary rocks is thus divided by an angular extension of the Pre-Cambrian shield into two areas, a larger one to the south, including the "southwestern peninsula" and a smaller one between the Ottawa and St. Lawrence Rivers, a

MAP 1.

SUBDIVISIONS OF ONTARIO (from Snyder, '38.)

part of the St. Lawrence Lowlands. These two areas constitute the principal agricultural regions of the Province.

From a zoogeographical standpoint Southern Ontario is divided, according to Merriam, into three zones: Carolinian, Alleghanian and Canadian. The boundary lines of these zones are somewhat arbitrary, especially (in Ontario) that between the Alleghanian and Canadian. This boundary is in fact so nearly coincident with the line which separates Southern and Middle Ontario that we shall not deal with the Canadian zone as a separate region in this section, but consider under Southern Ontario only the Carolinian and Alleghanian zones.

Carolinian Zone. A line drawn from Toronto to Sarnia may be taken as approximately the northern limit of the Carolinian zone, although many Carolinian species range more or less widely beyond this line.

In general, the Carolinian fauna, as represented in Ontario, is rich in Zygoptera and Libellulidae and comparatively poor in Corduliidae and Aeschnidae. Owing to the flatness of the region, pond species are abundant and the paucity of stream species has been intensified by the drying up of watercourses and the irregular flow of those which remain, due to overclearing of the land.

Examples of species restricted in Ontario to this region or rarely found beyond its limits are the following: *Hetaerina americana*, *Argia apicalis*, *A. tibialis*, *A. translata*, *A. sedula*, *Anomalagrion hastatum*, *Perithemis tenera*, *Libellula semifasciata*, *Pachydiplax longipennis*, *Celithemis eponina*, *Trapezostigma carolina*, *T. lacerata* and *Pantala hymenea*.

Among the commonest pond dragonflies are *Enallagma ebrium*, *Ischnura verticalis*, *Anax junius*, *Libellula pulchella*, *L. lydia*, *Sympetrum rubicundulum*, *S. obtrusum* and *Leucorrhinia intacta:* and of stream species, *Agrion maculatum*, *Argia moesta*, *A. violacea*, *Enallagma exsulans* and, in more sluggish waters, *E. antennatum* and *Ischnura verticalis*. Of the common gomphids, *Gomphus fraternus* abounds along the shallow reedy parts of the Lake Erie shore and occurs also in the larger rivers; *G. spicatus* and *furcifer* are abundant in the more marshy places, while *G. villosipes* is characteristic of sluggish muddy streams. *G. vastus* is known only from Pelee Island. The commonest corduliid is *Tetragoneuria c. cynosura*, and *Epicordulia princeps* is frequently met with. The only common species of the bronzy type is *Dorocordulia libera*, the Somatochloras being very rare. Of aeschnids *Anax junius* is by far the most abundant, *Epiaeschna heros* the most characteristic, while the commonest Aeschnas are *A. umbrosa* along shady streams and *A. constricta* in open

marshes. *A. mutata*, from the vicinity of Galt, is the only strictly Carolinian Aeschna.

A few distinctly boreal species reach this zone, e.g. *Coenagrion resolutum*, *Enallagma boreale* and *E. cyathigerum*. These, or at least the first two, range northward to the edge of the Arctic zone. In the south their season of flight is early and comparatively brief, before the swarms of more southern dragonflies have reached their climax.

Alleghanian Zone. The greater part of Southern Ontario north of the Carolinian zone belongs to the Alleghanian or Eastern Transition, although the fauna of the northernmost part of the Parry Sound District, Algonquin Park and Renfrew County is predominantly boreal.

In the agricultural regions or those underlain by sedimentary rocks, we find many southern species which are rare or absent northward. Examples are *Lestes inaequalis*, *Enallagma geminatum*, *E. antennatum*, *E. vesperum*, *Amphiagrion saucium*, *Epiaeschna heros*, *Gomphus villosipes*, *G. furcifer*, *G. fraternus*, *G. vastus* (Ottawa valley), *Libellula luctuosa*, *Erythemis simplicicollis* and *Sympetrum rubicundulum*. *Epicordulia princeps* reaches Georgian Bay in a form with the maculation of the wings reduced to a minimum.

The commonest large pond dragonflies are still *Anax junius*, *Libellula pulchella* and *L. lydia*, together with the more northern *L. quadrimaculata* and *L. julia*. The last species swarms in bog ponds and is even more abundant in the Pre-Cambrian region. The only common Leucorrhinia is the relatively southern *L. intacta*. The typical species of temporary ponds are *Lestes unguiculatus*, *L. dryas*, *L. forcipatus*, *Sympetrum decisum* and *S. obtrusum*, but all these are widely distributed forms, not specially characteristic of the Alleghanian zone.

Except in the absence of Hetaerina, Anomalagrion and all but two species of Argia, the Zygoptera are the same as in the Carolinian zone. *Enallagma hageni* is the most abundant of the species, followed closely by *E. ebrium*, *Nehalennia irene* and *Ischnura verticalis*, the last species being the most ubiquitous, with the longest seasonal range.

Entering the Pre-Cambrian Shield, we come upon a vast number of rock-margined lakes, channels, streams with alternating rapids and pools, marshes and bog ponds: a region teeming with dragonfly life.

The lakes of this region are largely expansions of streams and are characterized by a similar fauna to a considerable extent. Characteristic of both lakes and streams are, e.g., *Argia moesta*, *Boyeria grafiana*, *Basiaeschna janata*, *Hagenius brevistylus*, *Gomphus lividus*, *G. exilis*, *Dromogomphus spinosus*, *Helocordulia uhleri*, *Neurocordulia yamaskanensis*, *Didymops transversa* and *Macromia illinoiensis*. In the shallower and gentler rapids we have also *Agrion maculatum*, *Ophiogomphus*

rupinsulensis, *Gomphus brevis*, *Lanthus albistylus*, *Cordulegaster maculatus* and others: and in the quiet reaches *Agrion aequabile*, *Enallagma exsulans*, *Boyeria vinosa* and *Gomphus scudderi*. Most of these are found also in the agricultural regions, where suitable conditions obtain, but soon disappear from streams whose flow has become irregular and whose waters are muddy and silted.

The bogs produce several characteristic species, mostly forms of wider and more general distribution northward. *Leucorrhinia frigida* swarms in early summer in the sphagnum bog ponds, sometimes with *Nannothemis bella*, *Nehalennia gracilis* (both relatively southern) and others. *Leucorrhinia proxima* takes the place of *L. intacta* as the most generally distributed species of the genus, although the latter still occurs in the less acid waters. *Libellula julia*, *Cordulia shurtleffi*, *Tetragoneuria canis*, and *Gomphus spicatus* are among the most constant of the bog pond species of early summer, while in late summer few species are seen in the bogs except *Sympetrum* (chiefly *S. obtrusum* and *vicinum*), *Lestes*, particularly *L. disjunctus*, and *Aeschna canadensis*.

The Aeschnas of the Canadian zone (*A. eremita* and *interrupta*) begin to be common about the latitude of Algonquin Park, together with *Leucorrhinia hudsonica*, *L. glacialis* and some of the Somatochloras (*S. minor*, *elongata*, *williamsoni*, *kennedyi* and *forcipata*). The most abundant Corduliidae are the Tetragoneurias, *T. spinigera* and *T. cynosura simulans*.

Among the species that reach their northern limit approximately with that of the Alleghanian zone are the following: *Lestes vigilax*, *Enallagma exsulans*, *E. carunculatum*, *E. signatum*, *Nasiaeschna pentacantha*, *Aeschna constricta*, *A. verticalis*, *Dromogomphus spinosus*, *Libellula incesta*, *L. lydia*, *Nannothemis bella* and *Celithemis elisa*. Some of these, e.g. *E. exsulans*, *E. carunculatum*, *D. spinosus* and *L. lydia*, probably enter Central Ontario but have not yet been recorded. *L. incesta* and *C. elisa* appear to have a discontinuous distribution. The former is common on the shore of Lake Erie but is apparently absent throughout the agricultural region, reappearing on the Pre-Cambrian Shield (Muskoka District and Leeds County). *C. elisa* is also commonest in the extreme south but is extremely sporadic northward until the Pre-Cambrian Shield is reached, where it again becomes fairly common in open marshes and bogs.

In concluding this section on the Alleghanian zone, special mention may be made of the Ottawa River and its tributaries, this drainage system being probably the richest in Odonata in all Canada, especially in Gomphidae, these being for the most part river forms. Many of the species are eastern and southern but some are northern, notably in the

Mer Bleue, a huge peat bog, formerly a lake draining into the Ottawa. These species are, however, not Gomphidae but chiefly Corduliidae. Not all the species of the Ottawa valley, including its tributaries, have been found in Ontario, some, e.g., *Ophiogomphus mainensis* and *Gomphus amnicola*, being known only from the Quebec side. Of the species from Ontario, the following may be mentioned: *Gomphus vastus*, common on the Ottawa south of Arnprior, but elsewhere in Ontario known only from Pelee Island, Lake Erie; *G. ventricosus*, elsewhere in Canada known only from Farnham, Quebec, and Fredericton, N.B.; *G. spiniceps*, restricted in Canada to the Ottawa drainage system; and *Ophiogomphus anomalus* which has an apparently scattered distribution from Maine to the region of Lake Nipigon, north of Lake Superior. Northern dragonflies found in the Mer Bleue are *Somatochlora franklini*, *S. kennedyi*, *Williamsonia fletcheri* and *Leucorrhinia hudsonica*.

CENTRAL ONTARIO

Central Ontario lies wholly within the Canadian zone. Dragonflies have been collected from but few localities in this section of the Province, chiefly in the Timagami Forest Reserve and in the extreme west where Central and Western Ontario meet, viz., the vicinity of Lake Nipigon. These localities are similar in topography to other portions of the Pre-Cambrian Shield and the odonate fauna is much the same except for the loss of species already mentioned under the Alleghanian zone and with an increasing percentage of boreal species. Most of these boreal forms have been already mentioned under the Alleghanian zone, but they are for the most part somewhat local until the Canadian zone is entered. A very few new forms appear in Central Ontario.

Characteristic of the Canadian zone are the Aeschnas, Somatochloras and Leucorrhinias, the principal species of which are: *Aeschna eremita*, *interrupta*, *canadensis* and *umbrosa*; *Somatochlora walshii*, *minor*, *elongata*, *williamsoni*, *kennedyi*, *forcipata* and *cingulata*; *Leucorrhinia hudsonica*, *glacialis*, *proxima* and *frigida*. Other characteristic species are *Cordulia shurtleffi* and *Sympetrum danae*. *Williamsonia fletcheri*, reported from Timagami and from the Mer Bleue, as already noted, likewise appears to be a typically boreal species. The Hudsonian forms *Aeschna subarctica* and *A. sitchensis* are also beginning to appear and undoubtedly others will be found in the northern parts of Central Ontario.

On the other hand there are still many species of the Carolinian and Alleghanian zones which enter Central Ontario and probably reach their northern limits here. Among these are *Agrion maculatum*, *Lestes*

unguiculatus, *L. rectangularis*, *Argia moesta*, *A. violacea*, *Ischnura verticalis*, *Boyeria vinosa*, *Anax junius*, *Hagenius brevistylus*, *Ophiogomphus carolus*, *Lanthus albistylus*, *Gomphus lividus*, *G. scudderi*, *G. notatus*, *Cordulegaster diastatops*, *Dorocordulia libera*, *Somatochlora tenebrosa*, *Tetragoneuria c. simulans*, *Neurocordulia yamaskanensis*, *Didymops transversa*, *Macromia illinoiensis*, *Libellula pulchella*, *Sympetrum costiferum*, *vicinum* and *semicinctum*, and *Leucorrhinia intacta*.

WESTERN ONTARIO

In general the Odonata of Central and Western Ontario are similar but the cooling influence of Lake Superior is seen in the fauna of its north shore, which appears to be of a more boreal type than that of Central Ontario as represented by the Timagami region. Such southern forms as *Agrion maculatum*, *Argia moesta* and *A. violacea* are absent, while Hudsonian species such as *Coenagrion interrogatum*, *Aeschna juncea*, *subarctica* and *sitchensis*, *Ophiogomphus colubrinus* and *Somatochlora albicincta* are more or less common.

Tetragoneuria spinigera, a dominant species here, reaches its maximum size on the north shore of Lake Superior, where it is considerably larger than it is anywhere else across the continent, except perhaps in Northern Ontario. *Ischnura verticalis* is rare and local, doubtless at its northern limit, but *Nehalennia irene*, *Enallagma hageni* and *E. ebrium* are still common though more local than they are farther south.

West of Lake Superior, in the Rainy River District and adjacent parts of the Kenora District, the climate is distinctly milder and an incursion of southern species in the fauna is evident, as pointed out by Snyder (38b) with reference to the birds and mammals of this region. Practically no collecting of dragonflies has been done in the Rainy River District, but in the southern part of the Kenora District, viz., at Minaki, the dragonfly fauna is distinctly more southern than at Nipigon or Lake Nipigon. In fact several species occur there which inhabit only the more southern parts of Southern Ontario and are apparently absent, in that section of the Province, from the Pre-Cambrian Shield. Such are *Enallagma civile*, *Gomphus cornutus*, *G. graslinellus*, *G. fraternus* and *Tarnetrum corruptum*. These species are also present in eastern Manitoba (Walker '33), from which western Ontario also receives one characteristic species of the north central plains, viz., *Coenagrion angulatum*.

NORTHERN ONTARIO

In Northern Ontario parts of three faunal zones are represented, viz., the northern part of the Canadian, the entire width of the Hudsonian, which is narrowed here by the proximity of Hudson Bay; and the Arctic, represented by the immediate shore of the Bay.

Lake Abitibi and Smoky Falls, near Kapuskasing, are representative southern stations in Northern Ontario and are in the heart of the Canadian zone: the regions of Favourable Lake, Attawapiskat Lake and Moosonee, at the south end of James Bay, are middle stations, still within the Canadian but approaching the Hudsonian zone, while Fort Severn on Hudson Bay itself is typically Hudsonian and the only Ontario station within this zone from which collections of Odonata have been received.

Canadian Zone. In the northern belt of the Canadian zone, as represented in Northern Ontario, the genera are almost all holarctic and many of the species have near relatives in the palaearctic region.

The Zygoptera are reduced to but few species, nearly all diminishing in numbers northward. The principal species are *Agrion aequabile hudsonicum* (the only stream form), *Lestrs disjunctus*, *L. dryas*, *Enallagma boreale*, *E. cyathigerum*, *Coenagrion resolutum* and *C. interrogatum*. Other species which are already almost at their northern limits as we enter Northern Ontario are *Lestes congener*, *L. forcipatus*, *Nehalennia irene*, *Enallagma hageni*, *E. ebrium* and *Chromagrion conditum*. These are all species that range southward well beyond the Canadian boundary.

Of the Anisoptera, Aeschna, Somatochlora, Leucorrhinia and Sympetrum are dominant genera.

The Aeschnas are the same as those of Central and Western Ontario but *A. canadensis* is rare and local while the Hudsonian species are increasing northward. *A. eremita*, *interrupta* and *umbrosa* are still common. The only other aeschnids are *Boyeria grafiana*, which persists well down the Hudson Bay slope, and *Basiaeschna janata*, which reaches its known northern limit at Favourable Lake.

Somatochlora reaches its maximum development at this latitude, at least in number of individuals. *S. cingulata*, the large lake species, and *S. franklini*, the small frail species of the muskegs, are both abundant and characteristic forms. *S. albicincta* is also increasing as we travel northward and its ally from the west, *S. hudsonica*, is met with for the first time. The other species are those already mentioned in previous sections, except *S. tenebrosa* and *S. elongata*, which, however, is to be expected in the region. All except these species and *S. williamsoni*,

known as far north as Lake Abitibi, probably range at least to the edge of the Hudsonian, judging from their known distribution elsewhere.

Besides Somatochlora, the Corduliidae are represented by *Cordulia shurtleffi*, very abundant here, and the two Tetragoneurias, *T. spinigera* and *canis*, both of which appear to be at least locally common. *Helocordulia uhleri* has been taken as far north as Lake Abitibi.

Leucorrhinia, the third largest genus at this latitude, is another genus at its maximum development. *L. hudsonica* is here one of the most abundant dragonflies, *L. proxima* and *glacialis* are still at their optimum, and two other species have appeared, the large *L. borealis* from the west and the very small *L. patricia*. It is very probable that *L. frigida* will be found here also. Sympetrum is represented by at least three species, *S. decisum*, *S. obtrusum* and *S. danae*. *S. decisum* has been taken farthest north, viz., at Moosonee, but too little collecting has been done to attach any significance to this fact. The only other Libellulids are *Libellula quadrimaculata*, which is still plentiful and probably reaches the edge of the Hudsonian, and *L. julia*, which at least reaches the southern boundary of Northern Ontario, viz., at Lake Abitibi.

Two other families are still represented, viz., Gomphidae and Cordulegasteridae. Few Gomphidae are left when Northern Ontario is entered and all except *Ophiogomphus colubrinus* are almost at their northern limit. *O. rupinsulensis*, *Gomphus exilis*, *G. spicatus* and *G. brevis* are the only other species known at this latitude in Ontario. *Cordulegaster maculatus*, the only representative of its family, is common at least as far north as Lake Abitibi.

Hudsonian Zone. This is a zone of particular interest, as it is the region where dragonflies as a whole make their last stand in the face of the Arctic. In Ontario it occupies the coastal plain of Hudson Bay and is an almost continuous muskeg or bog, lacking the numerous lakes so characteristic of the Pre-Cambrian region immediately south of it.

In a collection of nearly 500 specimens from Fort Severn, Hudson Bay, there are fourteen species. The absence of any members of the genera Lestes and Sympetrum and the paucity of the larger Aeschnas are doubtless due to the fact that no collecting was done after July 31.

The Zygoptera consist of two species, *Coenagrion resolutum* and *Enallagma boreale*, of which the former was by far the more abundant. Both are represented by individuals of maximum size. The Anisoptera are represented by one species from the Severn River, *Ophiogomphus colubrinus*, and eleven from the muskeg, of which almost the entire region consists. These are *Aeschna eremita*, *A. juncea*, *A. coerulea septentrionalis*, *A. sitchensis*, *Somatochlora franklini*, *S. whitehousei*, *S.*

septentrionalis, *S. albicincta*, *S. hudsonica*, *Leucorrhinia hudsonica* and *L. patricia*. *L. hudsonica* was the most abundant species.

Thus there are three species not recorded south of this zone, viz., *Aeschna c. septentrionalis*, *Somatochlora whitehousei* and *S. septentrionalis*. These and all the others, except the newly described *L. patricia*, are widely distributed in the Hudsonian zone across the Continent. With the exception of *A. eremita*, *O. colubrinus*, *L. hudsonica*, the two Zygoptera and possibly *L. patricia*, these species are either peculiar to the Hudsonian zone or characteristic of it.

Other species in the Ontario list which are known to inhabit the Hudsonian zone in other parts of the Continent, such as Labrador, Manitoba and the Northwest Territories, are *Aeschna subarctica*, *Cordulia shurtleffi*, *Somatochlora minor*, *S. forcipata*, and *S. cingulata*. *Coenagrion interrogatum*, whose southern limit is the most northerly of all North American Zygoptera and which is a typical muskeg species, will also prove almost certainly to be a Hudsonian form. From their occurrence on the Quebec shore of James Bay at Rupert House, we believe also that *Lestes disjunctus* and *L. dryas* will be included in this group. They are at least found close to its border.

Methods followed in the list. It may seem unnecessary to record in detail the localities of common, widely distributed species, but we believe it to be desirable for two reasons: (1) definite information is thus given as to which species are the most generally distributed, and (2) the records are available to those who, in the future, may be making an intensive study of the Odonata of some limited area, where such definite data are needed. The practice of recording by counties only is doubtless satisfactory in the case of many State lists, but the counties and districts of Ontario are so unequal in size (see map 2), some of the districts being as large as a good-sized state of the Union, that this method was considered insufficient in dealing with a province as large in area as Ontario. Localities on the west side of Cook Bay, Lake Simcoe, where the writer's most intensive collecting has been done are included under this name. All of the species so recorded have been taken in the vicinity of De Grassi Point, near Lefroy, and many from within a radius of ten miles from this locality.

In regard to the details presented in the list of species, the following plan has been adopted. The names of collectors, or in some cases authors who have already published records, are indicated by initials in brackets, following the record. Where the name of the collector is unknown, the abbreviation (col.?) follows the record. Each record following the name of a county or district is separated from the next by a semicolon, with a period following the last record within a county or district. If no

initials precede the semicolon or period, it is understood that the present writer is responsible for the record: either he is the collector or one of a group of collectors, or the record has already been published under his name.

Besides the initials of collectors given below, the following abbreviations are used: Crk. (Creek), I. (Island), Is. (islands), L. (Lake), Pt. (Point), R. (River).

LIST OF COLLECTORS

Ainslie, G. D.	GDA
Atwood, C. E.	CEA
Baillie, J. L.	JLB
Baird, A. B.	ABB
Beaulieu, G.	GB
Bigelow, N. K.	NKB
Bowman, N.	NB
Brown, A. W. A.	AWAB
Brown, W. J.	WJB
Cain, R. F.	RFC
Cormack, R. G. H.	RGHC
Curran, C. H.	CHC
Denike, W. N.	WND
Downing, S. C.	SCD
Dymond, J. R.	JRD
Evans, J. D.	JDE
Fiske, G. H.	GHF
Fletcher, J.	JF
Ford, N.	NF
Fraser, W. J.	WJF
Freeman, G. M.	GMF
Gibson, A.	AG
Hahn, P.	PH
Hanes, C. S.	CSH
Harkness, W. J. K.	WJKH
Harrington, W. H.	WHH
Hart, J. L.	JLH
Henderson, V. E., Jr.	VEH
Hewitt, C. G.	CGH
Hope, C. E.	CEH
Huntsman, A. G.	AGH
Hutchings, C. B.	CBH
Ide, F. P.	FPI
Ireland, N. J.	NJI
Jennings, G. K.	GKJ
Johansen, F.	FJ
Kirk, M. D.	MDK
Laird, H. C.	HCL
LaRocque, A.	AL
LeRay, W.	WL
Letourneaux, J. A.	JAL
Logier, E. B. S.	SL
McDunnough, J. H.	JHM
McEwen, J. K.	JKM
MacLulich, D. A.	DAM
Miller, R. B.	RBM
Milne, L. J.	LJM
Neal, G. M.	GMN
Ontario Fisheries Research Laboratory	OFRL
Oughton, J. G.	JGO
Ozburn, R. H.	RHO
Pentland, E. S.	ESP
Petersen, O. A.	OAP
Pettigrew, M.	MP
Prince, L. A.	LAP
Pritchard, A. L.	ALP
Rawson, D. S.	DSR
Richardson, A. W.	AWR
Ricker, W. E.	WER
Robertson, A. D.	ADR
Root, F. M.	FMR
Sanders, G.	GS
Scott, W. B.	WBS

Sells, E. S.	ESS	White, J.	JW
Stewart, D.	DS	Wilkes	AW
Stöhr, L. M.	LMS	Williamson, E. B.	EBW
Thompson, S. L.	SLT	Wilson, W. J.	WJW
Troyer, S.	ST	Wodehouse, R. P.	RPW
Viereck, H. H.	HLV	Young, C. H.	CHY
Walley, G. S.	GSW	Young, O. E.	OEY
Whelan, R. V.	RVW	Younger, R.	RY
White, H. T.	HTW	Zetter, L.	LZ

ZYGOPTERA

AGRIIDAE

1. **Agrion* maculatum** Beauv.

ESSEX: Leamington. KENT: Bothwell (LJM); Orford twp.; Morpeth. ELGIN: St. Thomas; Springer Crk.; Port Stanley; Port Bruce; Port Burwell. MIDDLESEX: Wardsville. NORFOLK: Port Ryerse. OXFORD: Thamesford. BRANT: Glen Morris (NF); Princeton. HALDIMAND: Oneida twp.; Caledonia. WELLAND: Niagara Falls. LINCOLN: St. Catharines. WATERLOO: Kitchener; Galt. WENTWORTH: Hamilton. HALTON: Georgetown; Milton; Palermo. HURON: Auburn. WELLINGTON: Guelph. PEEL: Erindale; Credit Forks; Bolton; Palgrave. YORK: Toronto; Kleinburg; Pottageville; North York twp.; Vandorf; Maskinonge River. ONTARIO: Glen Major (WER); Claremont. BRUCE: Stoke's Bay (NF). GREY: Owen Sound. SIMCOE: Nottawasaga R. near Alliston; Cook Bay, L. Simcoe; Tioga; Singhampton (WER); Orillia (CHC). HASTINGS: Belleville; Shannonville. LEEDS: Brockville. LANARK: Perth. PRESCOTT: L'Orignal. CARLETON: Ottawa; Britannia Bay; Cyrville. MUSKOKA: Go Home Bay; Kahshe R.; Baysville; Port Sydney (NBK). PARRY SOUND: Kearney (FPI); Sand Crk., L. Nipissing. RENFREW: Little Tucker Crk.; Heeney Crk. NIPISSING: headwaters of French R.; Algonquin Park (JHM et al.); Sturgeon R. (JF); Lake Timagami (AWAB). ALGOMA: Thessalon; Heyden and Searchmont (EBW); Silver Falls (col.?); Blind R. (PH).

Small streams with intermittent rapids or riffles, more or less shaded; very abundant in Southern Ontario, local northward and not definitely known north of Lake Superior.

It appears at Toronto towards the end of May, becoming abundant in late June and remaining in a few favourable situations until nearly the end of August. Earliest and latest dates: May 27 (Toronto) and August 29 (DeGrassi Point).

*In recent publications, the writer has used the name *Calopteryx* for this genus, following the practice of European authors, *Agrion* being applied to the genus here termed *Coenagrion*. Since the present indications are that *Agrion* will soon be universally employed in place of *Calopteryx*, we have reluctantly decided to return to this practice.

2. **Agrion aequabile** (Say).

MIDDLESEX: London. OXFORD: Thamesford. BRANT: Glen Morris (NF). WATERLOO: Kitchener. HURON: Auburn. WELLINGTON: Guelph. PEEL: Erindale YORK: Don R., North York twp. DUFFERIN: Horning's Mills (FPI, WER). PRINCE EDWARD: Bloomfield. GREY: Owen Sound. SIMCOE: Nottawasaga R. near Alliston; Cook Bay, L. Simcoe; Victoria Harbour; Singhampton (WER). HASTINGS: Belleville; Shannonville. FRONTENAC: Arden. LEEDS: Brockville; Lyn (GSW). LANARK: Perth; Fall River. CARLETON: Carlsbad Springs (FPI); Ottawa; Cyrville. PARRY SOUND: Kearney (FPI); Sand Crk., L. Nipissing. RENFREW: Petawawa Forest Res. (VEH); Big Tucker and Little Tucker Crks. NIPISSING: Algonquin Park: Lake Timagami. THUNDER BAY: Gull R. (CSH); Orient Bay, L. Nipigon; Silver I., L. Superior. COCHRANE: Nagagami R. and Kenogami R. near mouth of Flint R. (WJW); Onakawana; Smoky Falls (RVW); Moosonee (SCD). KENORA, Patricia section: Kapiscau R., 180 miles up; Favourable Lake region.

The two races *aequabile* and *hudsonicum* are not clearly defined. In general *aequabile* inhabits southern Ontario but some individuals from the Nipissing District approach *hudsonicum* closely. Typical *hudsonicum* is represented by the specimens from Silver I., L. Superior, and the Hudson Bay slope (northern Kenora and Cochrane Districts).

Locally common, becoming abundant northward, preferring larger streams than *A. maculatum*, the nymphs apparently tolerating a lower temperature. It is, on the whole, a boreal species. The earliest and latest dates are June 3 (Petawawa) and Sept. 2 (Nagagami R.). In Simcoe Co. we have records from June 4 to Aug. 16. It undoubtedly emerges, however, before the end of May, earlier in fact than *A. maculatum*, since our earliest specimens have always been fully mature, while those of *maculatum* were teneral.

3. **Hetaerina americana** (Fabr.)

KENT: Thames R., Orford twp. LAMBTON: Sydenham R. near Alvinston (RFC). ELGIN: Port Bruce. MIDDLESEX: Thames R. at London and Wardsville; Melbourne. OXFORD: Tillsonburg. BRANT: Glen Morris (SLT). HALDIMAND: Grand R., Caledonia. PERTH: St. Mary's (GDA). HURON: Auburn. PEEL: Credit R. at Erindale.

Rapid streams with overhanging vegetation: Carolinian, scarcely entering the Transition zone. The recorded dates range from July 1 (Port Bruce) to Sept. 24 (Erindale and Glen Morris). Both tenerals and fully mature individuals were observed along the Credit River on July 7, 1933. It is very abundant on the Thames River.

LESTIDAE

4. **Lestes eurinus** Say

MUSKOKA: Norway Pt., L. of Bays, 11. VII. '20 (JHM).

Bog ponds, evidently exceedingly local in Ontario: apparently an Austral species.

5. **Lestes congener** Hagen.

WELLAND: Niagara Glen. PEEL: Credit Forks (WER); Inglewood (FPI). YORK: Toronto. ONTARIO: Glen Major (WER). SIMCOE: Holland R. marsh near Bradford; Cook Bay, L. Simcoe; Washago. CARLETON: Ottawa (JHM); Black Rapids, Rideau R. (FPI). MUSKOKA: Dudley; East R. PARRY SOUND: Nobel. RENFREW: Heeney Crk. NIPISSING: Algonquin Park; Obabika Crk., and Island Bay Crk., Timagami; North Bay (WER). ALGOMA: Searchmont (EBW). THUNDER BAY: Nipigon and Fort William (AGH). KENORA, Patricia section: Attawapiskat L.

Permanent and semi-permanent waters, widely distributed but seldom abundant. It appears late in the season, the dates ranging from Aug. 9 to Oct. 13. A single, newly-emerged male was taken on the Attawapiskat River on Aug. 13. This is the most northerly station known for this species.

L. congener oviposits in tandem on Typha and other plants far above the water line.

6. **Lestes unguiculatus** Hagen.

ESSEX: Pt. Pelee. KENT: Big Pt., L. St. Clair (SL & WL); Thames R. near Prairie Siding; Chatham. LAMBTON: Walpole I., R. St. Clair; Sarnia. ELGIN: St. Thomas (ABB). OXFORD: Tillsonburg. WATERLOO: Kitchener. HALTON: Bronte Crk. HURON: Auburn. WELLINGTON: Guelph. PEEL: Erindale; Snelgrove; Credit Forks; Gibson L. YORK: Summerville; Toronto; Thornhill; Kelly L. (NF). NORTHUMBERLAND: Cobourg (DS). BRUCE: Saugeen R. near Southampton. GREY: Meaford (ST). SIMCOE: Alliston; Cook Bay, L. Simcoe. HASTINGS: Belleville. CARLETON: Ottawa. MUSKOKA: Go Home Bay. PARRY SOUND: Frank's Bay, L. Nipissing. ALGOMA: Thessalon. THUNDER BAY: Silver I., L. Superior.

Still marshy waters, often abundant about temporary or semi-permanent ponds; mainly Carolinian and Transitional. The dates range from June 22 and 23 (Kelly L. and L. St. Clair) to Sept. 6 (Toronto). At DeGrassi Point, Lake Simcoe, where a large number of records have been obtained, it has been found emerging during the last week in June and remains until near the end of August. It oviposits in tandem, in Typha and other aquatic plants, high above water.

7. **Lestes dryas** Kirby (syn. *L. uncatus* Kby.)

ESSEX: Pt. Pelee. KENT: Rondeau Park (SL & WL). MIDDLESEX: London. BRANT: Dumfries S. twp. WATERLOO: Galt. WENTWORTH: Hamilton. HALTON: Bronte Crk. WELLINGTON: Guelph. PEEL: Erindale; Snelgrove; Credit Forks; Gibson L. YORK: Summerville; Toronto; Vandorf; West Hill. DUFFERIN: Horning's Mills (WER). GREY: Camperdown (NF). SIMCOE: Alliston; Essa twp.; Cook Bay, L. Simcoe; Wasaga Beach; Minnesing (WER). HASTINGS: Belleville. LEEDS: Brockville; Lyn (FPI). STORMONT: Cornwall (FPI). PRESCOTT: L'Orignal. CARLETON: Shirley's Bay (FPI); Ottawa; Carlsbad Springs; Cyrville;

Brittania Bay; Mississippi R. near Galetta. MUSKOKA: Go Home Bay; L. of Bays. PARRY SOUND: Kearney, Burk's Falls (FPI). RENFREW: Barbut Crk. MANITOULIN: Killarney (NF); Fitzwilliam I., Georgian Bay. NIPISSING: French R. headwaters; Algonquin Park. TIMISKAMING: Latchford. ALGOMA: Hayden and Searchmont (EBW). THUNDER BAY: Current R. near Port Arthur. COCHRANE: Lowbush, L. Abitibi; Smoky Falls (RVW); Nettitichi Pt., James Bay (ESP).

Generally distributed and very common about temporary or semi-permanent ponds, also less frequently in permanent marshy waters. It is the earliest Lestes to emerge, the dates ranging from May 30 (Rondeau Park) to Aug. 25 (Gilford). At Lake Simcoe and Toronto its observed period of emergence is from June 2 to 19. It is most abundant during late June and early July. It oviposits in tandem, high above the water, in various standing aquatic plants.

8. **Lestes disjunctus** Selys

ESSEX: Pt. Pelee. LAMBTON: Pt. Edward. MIDDLESEX: Midway Crk. near Arva. HURON: Aux Sables R. near Grand Bend. HALTON: Georgetown. PEEL: Inglewood (FPI); Credit Forks (WER); Snelgrove; Erindale; Gibson L. YORK: Mt. Dennis; Toronto; Kelly L.; Maskinonge R. BRUCE: Sauble Beach (NF). GREY: Thornbury. SIMCOE: Cook Bay, L. Simcoe. LEEDS: Brockville. CARLETON: Ottawa. MUSKOKA: Kahshe L.; Dudley; Go Home Bay and Giant's Tomb I., Georgian Bay; between Baysville and Bracebridge; L. of Bays (JHM); Port Sydney (NKB). PARRY SOUND: Nobel; Shawanaga; Point au Baril; Kearney (FPI); Frank's Bay, L. Nipissing. RENFREW: Stonecliffe. NIPISSING: headwaters of French R.; Algonquin Park; Obabika Crk. and L. Timagami (AWAB); Island Bay Crk. and Tomico R. (WER). TIMISKAMING: Timmins (NF); Latchford. THUNDER BAY: Orient Bay, L. Nipigon; Black Sturgeon L., Nipigon; Silver I.; Gull R. (CSH). COCHRANE: Lowbush, L. Abitibi. KENORA, Patricia section: Favourable L. region; Attawapiskat L.

Slow streams, marshy lakes and bog ponds, prevalent on acid soils; generally distributed and common north of the Carolinian zone; the common Lestes in the north. The recorded range of adult life is from July 5 (Favourable L.) to Sept. 21 (DeGrassi Pt.). It is most abundant in August.

9. **Lestes forcipatus** Rambur

ESSEX: Pelee I. (FMR, NF); Pt. Pelee (GSW). HALDIMAND: Caledonia. LINCOLN: Grimsby. PEEL: Snelgrove; Credit Forks; Erindale; Gibson L. YORK: Summerville; Toronto; Maskinonge R. BRUCE: Johnson's Harbour (WL); Sauble Beach (NF). SIMCOE: Cook Bay, L. Simcoe. CARLETON: Black Rapids, Rideau R. (FPI). MUSKOKA: L. of Bays (JHM). PARRY SOUND: Point au Baril. NIPISSING: Ko-ko-ko L., Timagami; Tomico R. TIMISKAMING: near Latchford. COCHRANE: Smoky Falls, Mattagami R. (RVW).

Ponds and quiet streams, frequently temporary pools; generally distributed and fairly common in the southern counties, local northward.

It was abundant at Johnson's Harbour in 1928 and at a small stream near Gilford in 1931. It is usually not very common in the vicinity of Lake Simcoe. June 16 (Gibson L.) to Sept. 6 (Toronto).

10. **Lestes rectangularis** Say

ESSEX: Leamington (WJB); Pt. Pelee; Belle R. KENT: Big Pt., L. St. Clair (SL & WL); Rondeau Park; Prairie Siding; Wallaceburg. MIDDLESEX: Arva. OXFORD: Tillsonburg. HALDIMAND: Caledonia. WELLAND: Gasline; Hewitt. HALTON: Bronte Crk. HURON: Auburn. PEEL: Snelgrove; Credit Forks. YORK: Toronto; Donalda Farm (ST). ONTARIO: Glen Major (FPI). GREY: Meaford (ST); Thornbury. SIMCOE: Cook Bay, L. Simcoe; Tioga; Washago; Atherly Narrows (DSR); Sebright (CHC). LEEDS: Lyn (GSW). PRESCOTT: L'Orignal. CARLETON: Ottawa; Black Rapids, Rideau R. (FPI). MUSKOKA: Kahshe L.; Dudley; Go Home Bay and Giant's Tomb I., Georgian Bay; Port Sydney; L. of Bays (JHM). PARRY SOUND: Nobel; Kearney (FPI); Frank's Bay, L. Nipissing. MANITOULIN: Fitzwilliam I. NIPISSING: Algonquin Park; Tomico R. KENORA: Minaki; Favourable L. region (seen).

Quiet permanent waters, preferring backwaters of shady streams; generally distributed and common in southern Ontario, more local northward; June 15 to Sept. 21 (DeGrassi Point). In this region (L. Simcoe), however, it usually appears about the middle of July and remains until the third week in September, if not later.

11. **Lestes vigilax** Hagen

ESSEX: Pt. Pelee. LAMBTON: Sarnia. MIDDLESEX: London. YORK: Toronto. LEEDS: Lyn (FPI). CARLETON: Rideau R. (JHM). MUSKOKA: Go Home Bay. MANITOULIN: Fitzwilliam I. NIPISSING: headwaters of French R.

Bog-margined lakes, apparently confined to southern Ontario, very local but usually abundant where it occurs. It has disappeared from Grenadier Pond, Toronto (a lake, not a pond), where it was abundant thirty years ago. June 16 to Aug. 26 (Go Home Bay).

12. **Lestes inaequalis** Walsh

ESSEX: Pt. Pelee. KENT: Rondeau Park. YORK: L. St. George. PRINCE EDWARD: East L. SIMCOE: Cook Bay, L. Simcoe. HASTINGS: Shannonville. LEEDS: Gananoque R., 4 mls. n. of Gananoque; Brockville; Lyn (FPI). CARLETON: Rideau R. (JHM). MUSKOKA: Go Home Bay. RENFREW: Snake R.

Slow streams and lagoons, flying farther out from shore than usual in this genus; mainly Carolinian, not uncommon at Point Pelee and Rondeau Park but, in general, somewhat rare and local. May 30 (L. St. George) to Aug. 6 (DeGrassi Pt.). It is an early species, having been taken only once after the end of July.

COENAGRIIDAE

13. **Argia moesta** (Hagen)

ESSEX: Pelee I. (NF, GSW). KENT: Thames R., in Orford twp. MIDDLESEX: Midway Crk. near Arva. OXFORD: Tillsonburg; Thamesford. BRANT: Glen Morris (NF). HALDIMAND: Grand R. at Caledonia. HURON: Maitland R. at Auburn and near Goderich; Egmondsville (JGO). WELLINGTON: Guelph. PEEL: Erindale; Credit Forks. YORK: Humber R. at Mt. Dennis; Don R. at Donalda Farm (ST). BRUCE: Saugeen R. near Southampton. GREY: Sydenham R., Owen Sound; Meaford (ST). SIMCOE: Nottawasaga R., Essa twp.; Stroud. PETERBOROUGH: Stony L.; Lovesick L. HASTINGS: Moira R. near Belleville. LEEDS: Brockville. LANARK: Perth. PRESCOTT: Nation R. at Plantagenet. CARLETON: Ottawa; Cyrville; Mississippi R. near Pakenham; Sand Hill, Rideau R. (FPI). MUSKOKA: Go Home Bay and Musquosh R.; Kahshe L.; Kahshe R.; Port Cockburn; Dorset; Norway Pt., L. of Bays (JHM); Port Sydney (NKB); Clear L., L. of Bays (FPI). PARRY SOUND: Frank's Bay, L. Nipissing. RENFREW: Petawawa R. (VEH); Arnprior. NIPISSING: Algonquin Park (JHM); Oxtongue R.; Joe L., Burnt Island L., Smoke L., Ragged L., all in Algonquin Park; Wap Crk., Algonquin Park (WER); Timagami L.; Gull Lake Torrent, Timagami (WER); Kaybuskong R.

Rapid streams, usually with projecting boulders, and the larger lakes with rocky shores; very abundant in southern Ontario but not known from western nor northern Ontario; absent from Lake Simcoe, although abundant on the Nottawasaga River.

At Erindale, on the Credit, *A. moesta* has been taken from June 7 to Sept. 12 and doubtless flies both earlier and later. On June 7, 1939, thousands of tenerals were flying in the river valley in this vicinity. Many had just emerged but some had evidently been flying for a few days. Some had scattered up the slopes of the valley nearly to the top. At Go Home Bay emergence was observed from about June 26 until July 5. Our latest recorded date is Sept. 19 (Port Cockburn).

14. **Argia apicalis** (Say)

KENT: Thames R. at Chatham; Orford twp.; Prairie Siding. ELGIN: St. Thomas. MIDDLESEX: Thames R. at London, Delaware and Wardsville. OXFORD: Tillsonburg (Otter R.); Ingersoll. HALDIMAND: Grand R. at Caledonia.

Rivers, frequenting quieter waters than *A. moesta*, usually with a soft bottom; abundant on the Thames. It flies over the vegetation along the banks and tends to wander a considerable distance from the water. It is a Carolinian species, reaching its northern limit in this part of the Province. The range of dates is from June 24 to Aug. 13. On June 24 and 25, 1934, the majority of individuals (at Chatham) were tenerals but a considerable number were fully coloured; while on Aug. 13, 1935, at the same locality, the great majority were mature but there were still many females that had no blue colour. The period of emergence thus appears to be a long one.

15. **Argia tibialis** (Rambur)

ELGIN: 2 mls. south of Wardsville (Middlesex), 17. VI. 1922, 2♂, 1♀.

Found along a small stream in company with *A. violacea*, *Enallagma exsulans* and *E. antennatum*. This species belongs strictly to the Carolinian zone and is evidently very rare in Ontario.

16. **Argia translata** Hagen

KENT: Thames R. near Chatham, 25. VI. 1934, 1♂, 1♀.

A pair in tandem were taken while ovipositing in a bed of *Myriophyllum* near the river bank. Another pair, recognized by its dark colour, was seen. Carolinian to Tropical, reaching its extreme northern limit here.

17. **Argia sedula** (Hagen)

KENT: Thames R. in Orford twp., 28. VI. 1934, and 12. VIII. 1935.

On the first date it was not uncommon along the banks of a sluggish part of the river. On the second date it was abundant in the shrubby vegetation close to the water, where the latter was three or four feet deep with a gentle current. Another strictly Austral species, not known elsewhere in Canada.

18. **Argia violacea** (Hagen)

ESSEX: Leamington. KENT: Bothwell (GSW); Thames R. in Orford twp.; Morpeth. ELGIN: Springer Crk.; Port Stanley; Port Bruce; St. Thomas. MIDDLESEX: Wardsville; Arva. OXFORD: Tillsonburg; Thamesford. BRANT: Princeton. HALDIMAND: Caledonia. LINCOLN: St. Catharines. WATERLOO: Galt (NF). HURON: Maitland R. at Egmondsville (JGO); Goderich; Auburn. PEEL: Snelgrove (JW); Erindale. YORK: Toronto. GREY: Owen Sound. SIMCOE: Nottawasaga R., Essa twp.; Cook Bay, L. Simcoe. LEEDS: Gananoque R. and St. Lawrence R., near Gananoque; Lyn (GSW). CARLETON: Ottawa. MUSKOKA: Go Home Bay; Port Carling; Baysville. PARRY SOUND: Shawanaga. RENFREW: Heeney Crk. NIPISSING: headwaters of French R.; Algonquin Park; Ko-ko-ko L., Timagami.

Small or shallow streams with a gentle current, especially those with a clay or stony bottom; common and generally distributed throughout southern Ontario. The earliest recorded date is June 16 (Leamington) The numerous dates recorded from Simcoe Co. range from June 30 to Aug. 19.

19. **Enallagma clausum** Morse

NIPISSING: Goose I., Sandy L. and other islands in Lake Nipissing near the headwaters of the French R., 11, 15. VII. 1929.

In lakes, in the above cases apparently developing from Scirpus beds; chiefly western in distribution.

20. **Enallagma boreale** Selys

WELLAND: Niagara Glen. WATERLOO: Kitchener. HALTON: Georgetown. WELLINGTON: Guelph. PEEL: Snelgrove; Gibson L. YORK: Toronto; Bond L.; Wilcox L. DUFFERIN: Horning's Mills (FPI, WER). SIMCOE: Cook Bay and Sand I. (DSR), L. Simcoe; Singhampton (WER). VICTORIA: Bobcaygeon (JHM). HASTINGS: Belleville. FRONTENAC: Silver L. LANARK: Perth; Innisville; Fall R. GLENGARRY: Lancaster (NJI). PRESCOTT: L'Orignal. CARLETON: Ottawa (JHM); Bell's Corners. MUSKOKA: Go Home Bay; L. of Bays (JHM) Baysville. MANITOULIN: Killarney (NF). NIPISSING: Goose I. and Sand L., L. Nipissing; French R. (WER); Algonquin Park; L. Timagami (AWAB). THUNDER BAY: Nipigon; Orient Bay, L. Nipigon; Current R. at Port Arthur (GKJ); Silver I. COCHRANE: Lowbush and Ghost R., L. Abitibi; Smoky Falls (RVW). KENORA: Minaki (JHM); Favourable L. region; Attawapiskat L.; Fort Severn, Hudson Bay (CEH).

Generally distributed but essentially boreal, an abundant and dominant species in the Canadian zone, where it frequents most of the quiet, marsh-bordered waters; more local southward, appearing in early spring in comparatively small numbers, before the swarms of *E. hageni* and *ebrium* have developed. The dates of adult life in southern Ontario range from May 16 (Wilcox L.) to July 9 (DeGrassi Pt.). The latest date recorded is Aug. 2 (Current R.) but it probably flies still later at this latitude and farther north. Northern specimens are larger and more robust than southern ones, the largest being from Fort Severn, on the coast of Hudson Bay.

21. **Enallagma cyathigerum** (Charp.)

NORFOLK: Long Pt. YORK: Toronto I.; Kelly L. DUFFERIN: Horning's Mills (WER). PRINCE EDWARD: East L. SIMCOE: DeGrassi Pt. LEEDS: St. Lawrence R. near Gananoque. MUSKOKA: Go Home Bay; L. of Bays (JHM). THUNDER BAY: Current R. at Port Arthur; Nipigon; Gull R. near L. Nipigon (CSH); Silver I., L. Superior. COCHRANE: Smoky Falls (RVW). KENORA, Patricia section: Favourable Lake region; Attawapiskat L.

Still marshy waters, common in the northwest, elsewhere scattered although sometimes locally plentiful. The earliest date is June 4 (Kelly L.). In the Thunder Bay District the dates range from June 18 to Aug. 8 (both at Nipigon). As in the case of *E. boreale* the size tends to increase northward.

22. **Enallagma hageni** (Walsh)

ESSEX: Point Pelee. KENT: Rondeau Park; Chatham. NORFOLK: Long Pt.; Normandale (GSW). OXFORD: Thamesford. HALDIMAND: Port Maitland (NF); Dunnville. WELLAND: Welland R. near Hewitt; Gasline; Chippawa; Niagara Falls; Niagara Glen. WATERLOO: Galt. PEEL: Snelgrove; Credit Forks. YORK: Toronto Kelly L.; Bond L.; Wilcox L.; Maskinonge R. ONTARIO: Rosebank (PH). PRINCE EDWARD: Sand Hills; East L.; West L. GREY: Meaford (ST). SIMCOE: Notta-

wasaga R., Essa twp.; Cook Bay, L. Simcoe; Wasaga Beach; Singhampton (WER). HASTINGS: Belleville. LEEDS: Brockville. LANARK: Perth. PRESCOTT: L'Orignal; Plantagenet. CARLETON: Ottawa; Mississippi R. near Galetta and Pakenham; Carlsbad Springs. MUSKOKA: Go Home Bay; Kahshe R. and L.; Mactier; between Baysville and Bracebridge; Dorset; L. of Bays (JHM). PARRY SOUND: Kearney (FPI); Frank's Bay, L. Nipissing. RENFREW: Moore L.; Petawawa Forest Res. (VEH). MANITOULIN: Killarney (NF); Fitzwilliam I. NIPISSING: islands in L. Nipissing and headwaters of French R.; Algonquin Park; Earl L. near Mattawa; L. Timagami, Ko-ko-ko L. and Lowell L., Timagami; near Tomico R.; 12 miles s. of Latchford; Twin Pine Camp, Ottawa R. ALGOMA: Heyden and Searchmont (EBW). SUDBURY: Gogama (JKM). THUNDER BAY: Fort William; Nipigon; Orient Bay, L. Nipigon; Gull R. (CSH); Silver I. COCHRANE: Lowbush, Long Point and Ghost R., L. Abitibi.

Generally distributed as far north as the Hudson Bay watershed; one of the most abundant of Ontario Zygoptera, frequenting marsh-bordered lakes, slow streams and sometimes bog ponds. The dates range from June 1 (Toronto) to Aug. 29 (L. Simcoe). It is most abundant in late June and July and the season of flight is practically over by mid-August.

23. **Enallagma geminatum** Kellicott

KENT: Thames R. in Orford twp. YORK: Toronto; Maskinonge R. SIMCOE: Cook Bay, L. Simcoe; Sebright (CHC). LEEDS: Lyn (FPI). MUSKOKA: 8 miles n.e. of Port Severn (OAP).

Quiet marshy streams and lakes, mainly Carolinian and very local in Ontario. It was not uncommon at Grenadier Pond about 30 years ago but has now almost disappeared. It has appeared only once at DeGrassi Pt. (Cook Bay), Lake Simcoe, during more than thirty years of collecting there, and then in very small numbers at the mouth of a quiet stream. It has been found on the Quebec side of the Ottawa River. June 28 (Thames R.) to Sept. 3 (Toronto).

24. **Enallagma ebrium** (Hagen)

ESSEX: Pt. Pelee; Belle R. KENT: Big Pt., L. St. Clair (SL & WL); Prairie Siding and Paincourt; Rondeau Park. ELGIN: St. Thomas; Springer Crk.; Port Stanley. MIDDLESEX: London. NORFOLK: St. Williams; Long Pt.; Normandale and Fisher's Glen (GSW). OXFORD: Tillsonburg; Ingersoll. BRANT: Dumfries S. twp. HALDIMAND: Port Maitland (NF). WELLAND: Niagara Falls. LINCOLN: Jordan (GSW). WATERLOO: Dumfries N. twp. HALTON: Georgetown. WELLINGTON: Guelph. PEEL: Snelgrove; Erindale; Credit Forks; Gibson L. YORK: Toronto; Wilcox L.; Kelly L.; Maskinonge R. DURHAM: Bethany. NORTHUMBERLAND: Cobourg. PRINCE EDWARD: Sand Hills; East L. GREY: Meaford (ST). SIMCOE: Nottawasaga R. near Alliston; Cook Bay, L. Simcoe; Singhampton (WER); Orillia (JHM). VICTORIA: Bobcaygeon (JHM). HASTINGS: Belleville; Shannonville; Black R. LEEDS: Gananoque R. and St. Lawrence R. near Gananoque; Brockville. PRESCOTT: Plantagenet. CARLETON: Ottawa; Carlsbad Springs; Brittania

(GB); Shirley Bay (CBH); Mississippi R. near Galetta and Pakenham. MUSKOKA: Go Home Bay; L. of Bays (JHM). PARRY SOUND: Nobel. RENFREW: Snake R. NIPISSING: bog ponds near headwaters of French R.; Algonquin Park; L. Timagami (AWAB). SUDBURY: Sudbury (JDE). THUNDER BAY: Silver I. COCHRANE: Smoky Falls (RVW). KENORA: Minaki.

Generally distributed and very abundant in southern Ontario, more local northward; frequenting still marshy waters, apparently preferring calcareous soils. In bog ponds and other acid waters it is much less common than *E. hageni* and is sometimes dwarfed. In general it is the most abundant Enallagma of still waters in extreme southern Ontario. The dates range from June 2 (Toronto) to Aug. 18 (DeGrassi Pt., pair in cop.). On June 2, 1936, many mature males were flying over a pond in the Don Valley, Toronto, but the great majority had recently emerged.

25. **Enallagma exsulans** (Hagen)

ESSEX: Belle R.; Puce. KENT: Thames R. at Chatham and in Orford twp.; Rondeau Park; Prairie Siding. ELGIN: St. Thomas; Springer Crk.; Port Stanley; Port Bruce. MIDDLESEX: Wardsville; Arva; London; Delaware. NORFOLK: Port Dover; Port Ryerse; St. Williams; Normandale (GSW). OXFORD: Tillsonburg; Thamesford; Putnam (GSW). BRANT: Princeton. HALDIMAND: Caledonia. WELLAND: near Niagara Glen. WATERLOO: Galt. HALTON: near Palermo. HURON: Aux Sables R. near Grand Bend; Maitland R. at Auburn and near Goderich; Egmondsville (JGO). PEEL: Erindale. YORK: Toronto; Woodbridge. ONTARIO: Glen Major (WER). NORTHUMBERLAND: Cobourg. BRUCE: Saugeen R. near Southampton. GREY: Thornbury. SIMCOE: Nottawasaga R. in Essa twp.; Cook Bay, and Sand I. (LSR), L. Simcoe; Severn (JHM). PETERBOROUGH: Lovesick L. HASTINGS: Belleville; Shannonville. LEEDS: Gananoque R.; Brockville; Lyn (GSW). LANARK: Perth. PRESCOTT: near Point Fortune, Que.; Plantagenet. CARLETON: Ottawa; Cyrville; Mississippi R. near Galetta and Pakenham. MUSKOKA: Go Home Bay; Kahshe R. and L. PARRY SOUND: Shawanaga; Frank's Bay, L. Nipissing. NIPISSING: Algonquin Park; Kaybuskong R.

Rivers and larger creeks with a gentle current, more rarely on lake shores; abundant throughout Southern Ontario and doubtless occurring farther north than the records indicate. June 11 to Sept. 7 (L. Simcoe); Sept. 19 (Woodbridge). It is most abundant from late June to early August.

26. **Enallagma carunculatum** Morse

ESSEX: Pelee I. (NF); Pt. Pelee (FMR); St. Joachim; Belle R. KENT: Rondeau Park; Johnson's Pt., Johnson R. LAMBTON: St. Anne and Walpole Is.; Courtright; Point Edward. NORFOLK: St. Williams; Normandale (GSW). HALDIMAND: Caledonia; Dunnville; Port Maitland (NF). WELLAND: Port Colborne. WENTWORTH: Burlington Beach. HURON: Egmondville (JGO). PEEL: Credit Forks (WER). YORK: Toronto; Donalda Farm, Don R. (ST); Kelly L. ONTARIO: Glen

Major (WER). BRUCE: Southampton. SIMCOE: Cook Bay, L. Simcoe. PETERBOROUGH: Lovesick L. HASTINGS: Belleville. CARLETON: Mackay L. and Rockcliffe (JHM). MUSKOKA: Go Home Bay; 8 miles n.e. of Port Severn (OAP); Kahshe R. PARRY SOUND: Frank's Bay, L. Nipissing. NIPISSING: Sandy I., L. Nipissing; Talon L. (FPI); Ottawa R. at Twin Pine Camp. KENORA: Minaki.

Rivers and lakes, frequenting Scirpus and Potamogeton beds in deeper water and often more exposed situations than is usual with Enallagmas; abundant and generally distributed in southern Ontario, occurring also in the extreme west. The earliest and latest dates are June 3 (Rockcliffe) and Sept. 25 (Toronto). At Lake Simcoe the season of flight usually begins about the first week of July and reaches its height in late July. Tenerals were observed at Burlington Beach on Aug. 29, 1935, and a few individuals doubtless fly in some seasons until the end of September. This species and *E. exsulans* are the common Enallagmas of late summer.

27. **Enallagma civile** (Hagen)

KENT: Thames R. 8 miles below Chatham; Prairie Siding; Orford twp. ELGIN: Port Bruce (NF). HALDIMAND: Dunnville. WELLAND: Port Colborne. YORK: Toronto, Simcoe Beach. KENORA: Minaki.

Rivers and lake shores, very local in Ontario where it is known only from the extreme south and the west; abundant in Manitoba. June 20 (Port Colborne) to Sept. 12 (Toronto).

28. **Enallagma aspersum** (Hagen)

MUSKOKA: Norway Pt., L. of Bays, 11. VII. 1920 (JHM); Huntsville (AW). NIPISSING: Algonquin Park (JHM).

A bog-pond species, extremely local in eastern Canada; mainly austral in distribution.

29. **Enallagma antennatum** (Say)

ESSEX: Pt. Pelee; St. Joachim; Belle R. KENT: Johnson's Point, Johnson R.; Prairie Siding; Thames R. at Chatham and in Orford twp. LAMBTON: St. Anne and Walpole Is.; St. Clair R. near Courtright; ELGIN: Port Stanley; Port Bruce; St. Thomas; Springer Crk. MIDDLESEX: Wardsville. OXFORD: Thamesford. HALDIMAND: Caledonia. WELLAND: Welland R. near Hewitt. WATERLOO: Kitchener; Galt. PEEL: Erindale. YORK: Toronto; Lambton; Don R. near Thorncliffe (JGO). NORTHUMBERLAND: Cobourg. SIMCOE: Nottawasaga R. in Essa twp.; Cook Bay, L. Simcoe. PETERBOROUGH: Peterborough. HASTINGS: Belleville; Shannonville. LEEDS: Gananoque R. DUNDAS: Iroquois. PRESCOTT: Plantagenet. CARLETON: Rideau R. (JHM); Carlsbad Springs; Cyrville; Mississippi R. near Galetta and Pakenham.

Abundant along quiet streams, especially in deep clay soils, Carolinian and Alleghanian, south of the Pre-Cambrian Shield. June 9 (Toronto) to Aug. 14 (Courtright).

30. **Enallagma signatum** (Hagen)

ESSEX: Pt. Pelee (GSW); Puce. KENT: Prairie Siding; Chatham; Orford twp. YORK: Toronto; Maskinonge R. BRUCE: Chesley L. (GSW). SIMCOE: Cook Bay, L. Simcoe; Waubaushene. HASTINGS: Belleville. LEEDS: Brockville (FPI); Lyn (GSW). CARLETON: Rideau R. near Ottawa (JHM); Shirley Bay (CBH). MUSKOKA: Go Home Bay. PARRY SOUND: mouth of Sand Crk., L. Nipissing. MANITOULIN: Killarney; Fitzwilliam I.

Broad, quiet streams, flying close to the water well away from the shore; doubtless generally distributed throughout southern Ontario. The earliest and latest dates are June 15 (Toronto) and Sept. 9 (Cook Bay), but it does not usually become common until late in July. Many tenerals as well as mature individuals appeared on the Thames River near Prairie Siding on Aug. 13, 1935.

31. **Enallagma vesperum** Calvert.

ESSEX: Pt. Pelee (FMR). KENT: Rondeau Park. YORK: Toronto; Maskinonge R. HASTINGS: Belleville. MUSKOKA: Go Home Bay.

Marshy lakes, lagoons and broad, quiet streams, very abundant at Point Pelee and formerly at Grenadier Pond, Toronto, local northward; chiefly a Carolinian species. June 18 (Pt. Pelee) to Aug. 29 (Toronto). Specimens from Point Pelee taken on June 18 were teneral or at least young and were taken on shore. Later they fly over the open water like *E. signatum*.

32. **Coenagrion resolutum** (Hagen)

ESSEX: Pt. Pelee (GSW). MIDDLESEX: London. HALDIMAND: Oneida twp. HALTON: Georgetown. PEEL: Lorne Park; Snelgrove; Erindale. YORK: Toronto; Kelly L.; Wilcox L. ONTARIO: Rosebank (PH). SIMCOE: Nottawasaga R. near Alliston; Cook Bay, L. Simcoe; Orillia (CHC). VICTORIA: Bobcaygeon (JHM). LEEDS: Brockville. LANARK: Innisville. PRESCOTT: L'Orignal. CARLETON: MacKay L., Rockcliffe (JHM); Ottawa; Mississippi R. near Galetta. MUSKOKA: L. of Bays (JHM); between Baysville and Bracebridge. RENFREW: Snake R.; Port Alexander. NIPISSING: Cache L. (JHM) and Joe L., Algonquin Park. ALGOMA: Little Carp R. THUNDER BAY: Nipigon; Orient Bay., L. Nipigon; Gull R. (CSH); Silver I. COCHRANE: Lowbush and Ghost R., L. Abitibi; Smoky Falls (RVW); tidal creek near Hurricanaw Bay, James Bay (ESP); Moosonee. KENORA: Minaki; Favourable L. and Attawapiskat L., Patricia Section; Fort Severn, Hudson Bay (CEH).

Still marshy or boggy waters, common and generally distributed in the north, more local southward, where the season of flight is early and brief, beginning before the end of May and usually over by the end of June. At Toronto and Lake Simcoe the dates range from May 23 (Toronto) to June 24 (DeGrassi Point) and there are records from bog ponds near Snelgrove and London as late as June 30 and July 1.

In the Favourable Lake region of Northern Ontario, it was found emerging on June 3, tenerals were taken on June 11, and mature individuals were found as late as July 21.

Specimens from Fort Severn are remarkably large and heavily marked, with the pale humeral stripes constantly divided.

33. **Coenagrion interrogatum** (Hagen)

THUNDER BAY: Nipigon; Orient Bay, L. Nipigon; Silver I., L. Superior. COCHRANE: Lowbush, L. Abitibi. KENORA: Minaki (JHM); Favourable L. region, Patricia section.

Cold bogs or muskegs, strictly boreal and probably found much farther north than the above records indicate. June 3 (Favourable L. region) to July 25 (L. Abitibi). Specimens taken on the first date were teneral.

34. **Coenagrion angulatum** Walk.

KENORA: Minaki, 4. VII. 1928 (JHM).

A boreal species of the Central Plains, probably ranging but a short distance into Western and doubtless Northern Ontario. It inhabits ponds and slow streams in deep soils.

35. **Nehalennia irene** Hagen

ESSEX: Pt. Pelee. KENT: Big Point, L. St. Clair (SL & WL); Rondeau Park. ELGIN: Port Stanley. MIDDLESEX: London. NORFOLK: Long Pt.; Fisher's Glen (GSW). OXFORD: Tillsonburg. BRANT: Glen Morris (NF). WELLAND: Niagara Falls. WATERLOO: Galt. HALTON: Georgetown. PEEL: Snelgrove; Credit Forks; Gibson L. YORK: Summerville; Toronto; North York twp.; Newmarket; Wilcox L.; Kelly L. DUFFERIN: Horning's Mills (FPI). ONTARIO: Rosebank (PH). NORTHUMBERLAND: Trenton (JDE). PRINCE EDWARD: East L. SIMCOE: Cook Bay, L. Simcoe. VICTORIA: Bobcaygeon (JHM). HASTINGS: Belleville. LEEDS: Brockville. PRESCOTT: L'Orignal. CARLETON: Ottawa; Carlsbad Springs. MUSKOKA: Go Home Bay and Giant's Tomb I., Georgian Bay; Norway Pt., L. of Bays (JHM); Baysville. PARRY SOUND: Frank's Bay, L. Nipissing. RENFREW: Snake R.; Port Alexander; Stonecliffe. NIPISSING: L. Nipissing (WER); French R. near headwaters; Algonquin Park; L. Timagami (AWAB). ALGOMA: Stony L. (EBW). THUNDER BAY: Orient Bay, L. Nipigon; Silver I.; Gull R. (CSH). COCHRANE: Lowbush and Ghost R., L. Abitibi. KENORA: Favourable Lake region.

Still marshy or boggy waters, especially peat bog ponds, where it is often exceedingly abundant; generally distributed northward to beyond the Hudson Bay watershed, but probably not reaching the northernmost regions of the Province, since it appears to be quite rare at the latitude of Lake Abitibi and Favourable Lake. The recorded dates, from May 22 (Toronto) to Aug. 19 (Cook Bay), appear to represent approximately the seasonal range in southern Ontario.

36. **Nehalennia gracilis** Morse

PEEL: Snelgrove. MUSKOKA: Go Home Bay.

Restricted to sphagnum bog ponds, extremely abundant in the vicinity of Go Home Bay; much less so at Snelgrove, where it is associated with *N. irene*. May 30 (Snelgrove) to Aug. 12 (Go Home Bay).

37. **Ischnura posita** (Hagen)

KENT: Aldborough twp. ELGIN: Port Stanley. MIDDLESEX: Arva; Delaware. OXFORD: Tillsonburg; Thamesford. WELLAND: Niagara Falls; St. Davids (GSW). PEEL: Credit Forks; Erindale. YORK: Toronto. DUFFERIN: Horning's Mills (CPI). ONTARIO: Whitby (GSW). GREY: Thornbury. SIMCOE: Cook Bay, L. Simcoe; Singhampton. LEEDS: Gananoque R., near Gananoque. CARLETON: Ottawa.

Spring bogs and slow, marsh-bordered streams, not uncommon in southern Ontario but never abundant. June 4 to Sept. 9 (Cook Bay). Most of the records were obtained at this locality.

38. **Ischnura verticalis** (Say)

ESSEX: Pt. Pelee; Belle R.; Puce; St. Joachim. KENT: Big Point, L. St. Clair (SL & WL); Prairie Siding; Dover Centre; Chatham; Orford and Aldborough twps.; Rondeau Park. LAMBTON: St. Anne and Walpole Is., St. Clair R.; Courtright; Point Edward; Sarnia. ELGIN: Port Bruce; Port Stanley; St. Thomas; Springer Crk. MIDDLESEX: Delaware; Arva; Wardsville. NORFOLK: Norfolk (TNF); Normandale (GSW); Long Pt.; St. Williams; Port Dover; Port Ryerse. OXFORD: Tillsonburg; Thamesford. BRANT: Princeton; Glen Morris. HALDIMAND: Caledonia; Dunnville; Oneida twp. WELLAND: Niagara Glen; Niagara Falls; Chippawa; Crystal Beach; Gasline; Port Colborne; Hewitt. LINCOLN: St. Catharines. WATERLOO: Galt. WENTWORTH: Hamilton; Burlington Beach; Alberton. HURON: Aux Sables R. near Grand Bend; Goderich; Auburn; Egmondville (JGO). PEEL: Snelgrove; Credit Forks; Erindale. YORK: Toronto; Thornhill; Kelly L.; Bond L.; Wilcox L.; near Holland Landing; Maskinonge R. DUFFERIN: Horning's Mills (WER). ONTARIO: Claremont; Glen Major (WER). NORTHUMBERLAND: Trenton (JDE); Cobourg. PRINCE EDWARD: Picton (NF); Bloomfield; Sand Hills; East L. GREY: Owen Sound; Thornbury; Meaford (ST); Camperdown (NF). SIMCOE: Nottawasaga R., Essa twp.; Cook Bay, L. Simcoe; Tioga; Atherly Narrows (DSR); Orillia (CHC); Singhampton (FPI); Washago. PETERBOROUGH: Havelock. HASTINGS: Belleville; Shannonville. FRONTENAC: Silver L. LEEDS: near Gananoque; Brockville; Lyn (GSW). LANARK: Fall R., Innisville; Perth. DUNDAS: Iroquois. PRESCOTT: L'Orignal; Plantagenet. CARLETON: Cyrville; Ottawa; Kettle I., Ottawa R.; Carlsbad Springs; Mississippi R. near Galetta and near Pakenham. MUSKOKA: Go Home Bay; Kahshe R.; Port Sydney; Port Carling; bog pond between Baysville and Bracebridge; Dorset; Black L. and Norway Pt., L. of Bays (JHM). PARRY SOUND: Sand Crk. and Frank's Bay, L. Nipissing. RENFREW: Snake R.; Port Alexander; Stonecliffe; Barbut Crk. NIPISSING: Algonquin Park; headwaters of French R.; Earl L. near Mattawa; Obabika L., Timagami. ALGOMA: Stony L. (EBW). THUNDER BAY: Nipigon; Orient Bay, L. Nipigon; Silver I.

Still, marsh-bordered streams, lakes and ponds; generally distributed throughout Southern Ontario, rare and local farther north and apparently not reaching the Hudson Bay watershed. In general, it is the commonest damsel-fly in southern Ontario. The seasonal range is the longest of any species, except *Anax junius*, the dates ranging from May 5 (Toronto) to Oct. 16 (DeGrassi Pt.). They do not usually appear, however, before May 15 or 20. While adults may emerge at any time during this period, the majority appear in early June and there is another lower peak of emergence in the second half of August.

39. **Anomalagrion hastatum** (Say)

OXFORD: Tillsonburg, Aug. 10, 1935. WELLAND: Point Abino (Van Duzee, '97, nec Williamson, '07).

A few young individuals, some just emerged, were taken from the edges of pools in an upland spring bog and a single individual from another small boggy pool in the valley of the Otter River.

40. **Amphiagrion saucium** (Burm.)

KENT: Bothwell (GSW). ELGIN: Port Stanley; Port Burwell. NORFOLK: Delhi and Normandale (GSW). OXFORD: Tillsonburg; Thamesford. BRANT: Glen Morris (NF). LINCOLN: St. Catharines. WATERLOO: Dumfries N. twp. WELLINGTON: Guelph. PEEL: Erindale; Credit Forks; Orangeville (WER). YORK: Summerville; Toronto. DUFFERIN: Horning's Mills (FPI). ONTARIO: Whitby; Glen Major (WER). BRUCE: Red Bay (NF). SIMCOE: Cook Bay, L. Simcoe. CARLETON: Ottawa; Cyrville.

Spring runs and springy bogs, common where its restricted type of habitat occurs. The earliest and latest dates on which adults have been recorded are June 11 (Gilford) and Aug. 8 (Summerville) but emergence certainly begins before the first of these dates.

41. **Chromagrion conditum** (Hagen)

ELGIN: Port Stanley. OXFORD: Thamesford. WATERLOO: Kitchener; Dumfries N. twp. PEEL: Erindale; Credit Forks. YORK: Summerville; Toronto; North York twp.; Maskinonge R. SIMCOE: Cook Bay, L. Simcoe. CARLETON: Ottawa. MUSKOKA: Go Home Bay; Black L., L. of Bays (JHM). PARRY SOUND: Sand Crk., Frank's Bay, L. Nipissing. RENFREW: Big Tucker Crk. NIPISSING: near headwaters of French R.; Algonquin Park. ALGOMA: Stony L. (EBW); Little Carp R. (col.?). COCHRANE: Long Pt., L. Abitibi.

Small shady streams, usually near springs; generally distributed. Emergence has been observed at Lake Simcoe from May 30 to June 12, and adults may be found until the middle or the third week of July. May 21 (North York twp.) to Aug. 4 (Stony Lake).

ANISOPTERA

AESCHNIDAE

42. **Boyeria vinosa** (Say)

HURON: Maitland R. at Auburn. PEEL: Credit Forks (WER); Inglewood (FPI). YORK: Highland Crk. SIMCOE: Nottawasaga R., Essa twp.; Cook Bay, L. Simcoe. LEEDS: Brockville (FPI); Lyn (GSW). MUSKOKA: Kahshe R. PARRY SOUND: Kearney (FPI); Shawanaga R. (PH); Sand Crk., Frank's Bay, L. Nipissing. NIPISSING: Grape L. (WER), Algonquin Park; Wilson L., 15 miles s. of L. Timagami (WER); streams entering L. Timagami (WER, JGO). ALGOMA: Heyden and Searchmont (EBW). COCHRANE: Kenogami R. (WJW).

The nymphs inhabit gently flowing streams, preferably with a stony bed and clear or peat-stained water; generally distributed and often common where these conditions obtain, e.g., in the Pre-Cambrian regions. The season is a late one, the dates ranging from July 13 (L. Nipissing) to Sept. 22 (Highland Crk.). It is most abundant in August and probably flies until October.

43. **Boyeria grafiana** Wmsn.

YORK: Jackson's Pt., L. Simcoe (DSR). ONTARIO: Balsam. BRUCE: Saugeen R. near Southampton. GREY: Sydenham R., Owen Sound. SIMCOE: Cook Bay, L. Simcoe. CARLETON: Ottawa (WHH). MUSKOKA: Go Home Bay; Bala (AGH); Port Cockburn; Glenmount, L. of Bays (FPI). PARRY SOUND: Frank's Bay, L. Nipissing; Shawanaga R. NIPISSING: Algonquin Park; Wilson L. (WER); L. Timagami; Lowell L. ALGOMA: Heyden and Searchmont (EBW); Blind R. (PH). THUNDER BAY: Orient Bay, L. Nipigon. COCHRANE: Nagagami R., 15 miles up (WJW).

Rocky margins of lakes and channels, and rapid streams, especially in the Pre-Cambrian regions, where it is abundant; common at DeGrassi Pt., along the boulder-strewn shore of Lake Simcoe. It is predominantly a species of lakes and swift, clear streams, being absent from the quieter streams where *B. vinosa* occurs. It is largely crepuscular in habit. The seasonal range is about the same as that of *B. vinosa.* The earliest date recorded is June 29 and the latest Oct. 8 (both at DeGrassi Pt., Cook Bay). Emergence was first observed at Go Home Bay on July 14 and usually begins at DeGrassi Pt. at about this time, the June record being an exceptional one. A pair in cop. was taken at this locality on Sept. 14.

44. **Nasiaeschna pentacantha** (Rambur)

WELLAND: Welland R. near Hewitt, 21. VI. '34, 1 ♀. LINCOLN: Jordan (GSW). SIMCOE: Waubaushene. VICTORIA: Bobcaygeon (JHM). MUSKOKA: Go Home Bay; Bala. NIPISSING: near headwaters of French R.

Quiet streams, channels and lakes, usually in forested regions, regional throughout southern Ontario, but very local. The dates range from June 21 (Welland R.) to July 16 (Go Home Bay) but the season of flight certainly begins much earlier, no tenerals having yet been taken.

45. **Epiaeschna heros** (Fabr.)

ESSEX: Pt. Pelee. KENT: Rondeau Park. ELGIN: Springer Crk. (seen). NORFOLK: Long Pt. WATERLOO: Dumfries N. twp. (seen). YORK: Toronto; Scarborough. NORTHUMBERLAND: Cobourg (AS). SIMCOE: Cook Bay, L. Simcoe. CARLETON: Ottawa region.

Nymphs were found in a small woodland pond at Scarborough and females have been observed ovipositing in partly shaded pools at the foot of a wooded slope, close to Grenadier Pond, Toronto, on June 12, 1936, and June 26, 1937. The dates range from June 7 (L. Simcoe) to July 3 (Pt. Pelee and L. Simcoe). It is scarcely more than a straggler as far north as Lake Simcoe, being essentially a Carolinian species.

46. **Basiaeschna janata** (Say)

ESSEX: Pt. Pelee (NKB). HALDIMAND: Oneida twp. WELLAND: Welland R. near Hewitt; Niagara Falls. HURON: Auburn. WELLINGTON: Guelph. YORK: Humber R. at Kleinburg; Kelly L.; Bond L.; Wilcox L. SIMCOE: Nottawasaga R., Essa twp.; Cook Bay, L. Simcoe; Atherly Narrows, Orillia (DSR); Severn (JHM). VICTORIA: Fenelon Falls (WER); Bobcaygeon (JHM). PETERBOROUGH: Madoc. HASTINGS: Shannonville; Black R. FRONTENAC: Silver L. LANARK: Fall R.; Innisville; Perth. LEEDS: Brockville; Portland (JHM). CARLETON: Ottawa (FPI); Mississippi R. near Pakenham. MUSKOKA: Go Home Bay; Kahshe R.; Port Sydney (RY); L. of Bays (JHM). PARRY SOUND: Kearney (FPI); Sand Crk., Frank's Bay, L. Nipissing; Shawanaga R. (PH). RENFREW: Big Tucker Crk. NIPISSING: islands in L. Nipissing, near headwaters of French R.; Algonquin Park. THUNDER BAY: Orient Bay and Ombabika Bay, L. Nipigon; Silver I., L. Superior. KENORA, Patricia section: Favourable L. region.

Forest streams and lakes, common and generally distributed. The season of flight is early, the dates ranging in southern Ontario from May 27 (Kleinburg) to July 12 (Go Home Bay). It is most abundant in June and has usually disappeared by the end of the month or early in July. In the Favourable Lake region of Northern Ontario two males were taken on July 20 and 29, 1938.

47. **Aeschna eremita** Scudd.

PEEL: Inglewood (FPI); Credit Forks (WER). YORK: Toronto; Kelly L. DUFFERIN: Horning's Mills (WER). SIMCOE: Holland R. marsh near Bradford; Cook Bay, L. Simcoe; Midland. MUSKOKA: Go Home Bay; L. of Bays. PARRY SOUND: Shawanaga R.; Frank's Bay, L. Nipissing. NIPISSING: Algonquin Park;

Watson L., Tomico R. and L. Timagami (WER); Ko-Ko-Ko L., Obabika Crk. and Lowell L., Timagami. ALGOMA: Heyden and Searchmont (EBW). THUNDER BAY: Nipigon; Black Sturgeon L.; Orient Bay, Shakespeare and Porphyry I., L. Nipigon; north end of L. Nipigon; Gull R. (CSH); Silver I., COCHRANE: Lowbush and Ghost R., L. Abitibi; Onakawana; Moosonee; Nettitichi Pt., James Bay (ESP). KENORA, Patricia section: Favourable Lake region; Attawapiskat L.; Fort Severn (CEH).

Forest lakes, slow streams and sometimes ponds; abundant in the Canadian and Hudsonian zones, occasional in the Transition, where it is smaller and more slender. It is an early species, the dates ranging from June 18 (Favourable L. region, 1♀, just emerged) to Sept. 27 (Toronto). It does not now occur so far south as Toronto and is only a straggler at Lake Simcoe. Most of the records from the north are for July.

48. **Aeschna interrupta interrupta** Walk.

PEEL: Inglewood (EPI); Credit Forks. ONTARIO: Glen Major (FPI, WER). SIMCOE: Cook Bay, L. Simcoe; 8 miles n.e. of Port Severn (OAP). HALIBURTON: Oxtongue R. MUSKOKA: Giant's Tomb I., Georgian Bay; L. of Bays. PARRY SOUND: Frank's Bay, L. Nipissing. RENFREW: Stonecliffe. NIPISSING: Algonquin Park (FPI); Watson L. (WER); Goose Is., L. Nipissing; Tomico R. (WER); L. Timagami (AWAB); Obabika L., Timagami. TIMISKAMING: Latchford. ALGOMA: Heyden and Searchmont (EBW); Sault Ste. Marie; Blind R., Mississauga R. (PH). SUDBURY: Sudbury. THUNDER BAY: Nipigon; Orient Bay and Ombabika Bay, L. Nipigon; Fort William; Gull R. (CSH). COCHRANE: Lowbush, L. Abitibi; Moosonee (GSW). KENORA, Patricia section: Favourable L. region.

Shallow marshy bays and lakes, breeding among emergent vegetation; abundant in the Canadian zone, local in the Transition. It emerges later than *A. eremita*, not usually appearing before the middle of July and reaching its greatest abundance in August. The earliest date is July 11 (Lake Nipissing, Favourable Lake,) the latest Sept. 20 (Sault Ste. Marie).

The long series from the Favourable Lake region includes all intergrades between this race and the next (Walker, '40).

48a. **Aeschna interrupta lineata** Walk.

COCHRANE: Lowbush, L. Abitibi, 2♀. KENORA, Patricia section: Favourable L. region.

This is the race characteristic of the Central Plains, where it is the commonest Aeschna. Most of the individuals from the Favourable Lake region are more or less intermediate between the races *interrupta* and *lineata* but some are definitely *lineata*.

49. **Aeschna clepsydra** Say

ESSEX: Pt. Pelee. NORTHUMBERLAND: Trenton (JDE). SIMCOE: DeGrassi Pt., Cook Bay. MUSKOKA: Go Home Bay.

Open marshes, very rare in Ontario; Alleghanian, apparently commonest on the Atlantic seaboard. The few recorded dates range from July 19 to Sept. 12. Emergence has been observed on July 25 and 28.

50. **Aeschna canadensis** Walk.

ESSEX: Pt. Pelee. KENT: Rondeau Park. PEEL: Credit Forks; Snelgrove. YORK: Toronto; Scarborough; Maskinonge R. DUFFERIN: Horning's Mills (FPI). ONTARIO: Glen Major (FPI, WER). NORTHUMBERLAND: Cobourg (DS). BRUCE: Tobermory; Southampton. GREY: Owen Sound. SIMCOE: Holland R. marsh; Cook Bay, L. Simcoe; Midland; Severn (JHM); 8 miles n.e. of Port Severn (OAP). LEEDS: Brockville. CARLETON: Ottawa; Mer Bleue (FPI). MUSKOKA: Kahshe L.; Go Home Bay; Giant's Tomb I., Geo. Bay; Bala; L. of Bays (JHM). PARRY SOUND: Nobel; Shawanaga; Frank's Bay, L. Nipissing. RENFREW: Heeney Crk.; Stonecliffe. NIPISSING: near headwaters of French R.; Twin Lakes near North Bay (WER); Watson and Godda L. (FPI) and Wap Crk., Algonquin Park (WER); L. Timagami (AWAB), near Tomico R. TIMISKAMING: Latchford. ALGOMA: Heyden and Searchmont (EBW). THUNDER BAY: Fort William; Nipigon; Grand Bay, Orient Bay and Black Sturgeon Bay, L. Nipigon; Silver I., L. Superior. KENORA: Minaki; Favourable L. region (Patricia section).

Open marshes bordering lakes and slow streams, or bog ponds; generally distributed south of the Hudson Bay watershed, most abundant in the Transition zone, where it is the dominant Aeschna of the marshes, diminishing in numbers in the Canadian zone, where it is gradually replaced by *A. eremita* and *interrupta*. The season of flight is long; emergence beginning before the end of June and continuing during the first half of July. The dates range from June 21 (L. Nipissing) to Sept. 27 (Toronto). It appears to emerge about as early in the northern as in the southern part of its range.

51. **Aeschna verticalis** Hagen

ESSEX: Pt. Pelee. YORK: Toronto; Scarborough; Highland Crk. BRUCE: Southampton; Dorcas Bay (JLB). SIMCOE: Holland R. marsh; Cook Bay, L. Simcoe; Hawkestone (WER). LEEDS: Near Gananoque. CARLETON: Mer Bleue (JHM). MUSKOKA: Go Home Bay.

Ponds with emergent vegetation; a later and more southern species than *A. canadensis;* local though occasionally abundant. The scarcity of records from extreme southern Ontario is doubtless due to lack of collecting during the season of flight. Apart from a newly emerged male seen near Gananoque on June 21, 1936, the range of dates is from July 17 (DeGrassi Pt.) to Oct. 11 (Ashbridge's marsh, Toronto). Most of the records are for August and September.

52. **Aeschna tuberculifera** Walk.

YORK: Etobicoke Crk.; East Toronto. SIMCOE: Cook Bay, L. Simcoe. MUSKOKA: Go Home Bay; Clearwater L. near Port Sydney; L. of Bays.

A rare and local species, not known north of the Transition zone. The only Ontario locality from which more than a single specimen has been taken is DeGrassi Pt. (Cook Bay), L. Simcoe, where it has been captured on four occasions. A female was taken while ovipositing at the edge of a forest pond near Norway Pt., Lake of Bays. The ovipositor is thrust into emergent aquatic plants below the surface of the water as in most Aeschnas.

53. **Aeschna juncea americana** Bart.

THUNDER BAY: Nipigon. COCHRANE: Lowbush, L. Abitibi; Moosonee. KENORA, Patricia section: Fort Severn (CEH).

Strictly boreal, being characteristic of the upper Canadian and Hudsonian zones, where it is common. It develops in still waters among emergent vegetation, both in larger bays or rivers and small, boggy sloughs. Our dates (July 10 to Aug. 30) probably do not cover the entire season of flight. In Northern Manitoba *A. juncea* emerges somewhat later than either *A. eremita* or *A. interrupta* and this is probably true in Ontario also.

54. **Aeschna subarctica** Walk.

SIMCOE: DeGrassi Pt., Cook Bay, L. Simcoe. NIPISSING: Obabika Crk., Timagami. THUNDER BAY: Nipigon. COCHRANE: Ghost R., L. Abitibi.

A species of the same faunal belt as *A. juncea*, probably occurring a little farther south, though the single specimen from DeGrassi Pt. was doubtless a wanderer from a long distance. Both species range to Hudson Bay, although *A. subarctica* is not known from the Ontario part of that region. July 7 (Ghost River, a newly emerged female) to Sept. 11 (Timagami). From observations in northern Manitoba it apparently emerges a little later than *A. juncea*.

55. **Aeschna sitchensis** Hagen

SIMCOE: DeGrassi Pt. ALGOMA: Sault Ste. Marie. THUNDER BAY: Silver I. COCHRANE: Smoky Falls, (GSW); Smooth Rock Falls, between Hearst and Cochrane (WER); Grand Rapids, Mattagami R. (WJKH); Ship Sands, near mouth of Moose R. (ESP); Nettitichi Pt., James Bay (ESP); Moosonee. KENORA, Patricia section: Favourable Lake region; Attawapiskat L.; Fort Severn (CEH).

Muskegs or sphagnum bogs, Hudsonian and northern parts of Canadian zone. The single individual from Lake Simcoe was undoubtedly a straggler from a long distance north and the record from

Sault Ste. Marie may be considered as being approximately at the southern limit of its distributional area. The dates range from June 25 (Favourable L.) to Aug. 19 (Grand Rapids, Mattagami R.).

56. **Aeschna coerulea septentrionalis** Burm.

KENORA, Patricia section: Fort Severn, Hudson Bay (CEH).

A series of 16♂, 21♀ was taken from July 3 to 27, 1940, in the muskeg which covers most of the country at this latitude.

A. coerulea is a circumpolar species, the race *septentrionalis* being a strictly Hudsonian form which ranges across the continent from Newfoundland and Labrador to the Mackenzie delta (Aklavik) and extreme northern British Columbia (Atlin) where it was taken recently by F. C. Whitehouse.

57. **Aeschna umbrosa umbrosa** Walk.

KENT: Orford twp. MIDDLESEX: London. LINCOLN: Grimsby. HURON: Auburn. WELLINGTON: Guelph. YORK: Summerville; Toronto; Scarborough; Highland Crk.; Pottageville; Maskinonge R. DUFFERIN: Horning's Mills (WER). ONTARIO: Glen Major (FPI, WER); Claremont. DURHAM: Oshawa. NORTHUMBERLAND: Cobourg (DS). BRUCE: Kincardine; Johnson's Harbour (WL); Saugeen R. near Southampton. GREY: Camperdown (NF); Thornbury; Owen Sound. SIMCOE: Nottawasaga R., Essa twp.; Holland R. marsh; Cook Bay, Wasaga Beach; Singhampton (WER). LEEDS: Brockville; Lyn (FPI, GSW). CARLETON: Ottawa (FPI). HALIBURTON: (JGO). MUSKOKA: Go Home Bay; Rostrevor; Port Sydney; East R.; near Bracebridge; Port Cockburn. PARRY SOUND: Point au Baril; Sand Crk., Frank's Bay, South Bay and Minas Bay, L. Nipissing; Mud L. (WER). NIPISSING: Goose Is., L. Nipissing; Grape L. (WER), L. Traverse (JRD), Square L. (JRD), Godda L. (FPI), Oxtongue R. and Little Joe Crk., Algonquin Park; Tomiko R.; Lowell L. and Obabika Crk., Timagami; L. Timagami (AWAB). THUNDER BAY: Fort William; Nipigon; Orient Bay, Grand Bay, Black Sturgeon Bay, Shakespeare I. and Wabinosh, L. Nipigon; Silver I., L. Superior. RAINY RIVER: Rainy River. COCHRANE: Hughes Station, near Cochrane; Lowbush, L. Abitibi; Smoky Falls, Mattagami R. (RVW). KENORA, Patricia section: Favourable L. region; Attawapiskat L.

Generally distributed and abundant, developing usually in more or less shady forest streams, both warm and cold; adults crepuscular, although they fly also by day in more or less shady places and in the sun as the weather becomes cooler in September and October. Emergence is irregular, adults usually appearing early in July and remaining until October. The earliest date is June 27 (Brockville) and the latest Nov. 1 (Toronto). I have known individuals to emerge as late as September.

58. **Aeschna constricta** Say

ESSEX: Pt. Pelee; Leamington (GSW). KENT: Dover Centre. LAMBTON: Point Edward. WELLINGTON: Guelph. PEEL: Credit Forks (WER); Inglewood (FPI). YORK: Toronto; Scarborough; Maskinonge R. ONTARIO: Glen Major

(WER). NORTHUMBERLAND: Cobourg (DS); Trenton (JDE). GREY: Camperdown (NF). SIMCOE: Holland R. marsh; Cook Bay. DUNDAS: south branch of Nation R. CARLETON: Ottawa. MUSKOKA: Kahshe R.

Open marshes, bordering slow streams and lakes, often wandering far afield; common in the Transition and Upper Austral zones. The dates range from July 26 and 27 (Ottawa and Pt. Pelee) to Oct. 11 (Toronto). Adults appear to be at the peak of their abundance in late August and early September.

59. **Aeschna mutata** Hagen

BRANT: Dumfries S. twp., near Glen Morris. 26 VI. 1939, 1♂.

Another was seen at this same spot, and, on the following date, a few miles north and east in Waterloo County, Dumfries North twp. Marshy ponds and swamps, Carolinian; apparently resident in this part of the Province and doubtless occurring elsewhere in extreme southern Ontario.

60. **Anax junius** (Drury)

ESSEX: Pelee I. (FMR); Pt. Pelee; St. Joachim; Belle R.; Puce. KENT: Dover Centre; Rondeau Park; Chatham; Orford twp. ELGIN: Port Stanley. NORFOLK: Long Point; St. Williams; Normandale (GSW). HALDIMAND: Oneida twp.; Dunnville; Caledonia. WELLAND: Hewitt; Gasline; Chippawa; Niagara Falls. HURON: Aux Sables R. near Grand Bend. WELLINGTON: Guelph. PEEL: Snelgrove; Credit Forks; Erindale; Gibson L. YORK: Toronto; Scarborough; Thornhill; Kelly L.; Wilcox L. DUFFERIN: Horning's Mills (WER). DURHAM: L. Scugog; Oshawa. NORTHUMBERLAND: Cobourg (DS); Trenton (JDE). PRINCE EDWARD: Sand Hills; East L. BRUCE: Johnson's Harbour (WL). SIMCOE: Holland R. marsh; Cook Bay, L. Simcoe; Wasaga Beach; Orillia (DSR); Rye R., Midland. VICTORIA: Fenelon Falls (WER). HASTINGS: Belleville. FRONTENAC: Kingston (NF). LEEDS: Brockville. PRESCOTT: Plantagenet. CARLETON: Ottawa (JHM); Mississippi R. near Galetta and near Pakenham. MUSKOKA: Go Home Bay; Muskoka Mills. PARRY SOUND: Frank's Bay and West Bay, L. Nipissing. RENFREW: Snake R. THUNDER BAY: Silver I., L. Superior.

Ponds, marshy lakes and slow streams, very abundant in the southernmost counties but decreasing in numbers northward and entering the Canadian zone only a short distance except as a wanderer; an austral species of very wide distribution. Emergence takes place in the second half of August and September, adults usually disappearing in late September and October, evidently migrating southward, since they are rarely seen with mature colours until the following spring, when they reappear in early May (rarely in April) and fly until August. The earliest recorded date is April 15, the latest Oct. 18 (Toronto). Even at this date the colours were not yet mature, the blue spots of the abdomen being still dull grey.

GOMPHIDAE

61. **Hagenius brevistylus** Selys

YORK: Toronto. NORTHUMBERLAND: Trenton (JDE). SIMCOE: Cook Bay and Sand I. (DSR), L. Simcoe; Sebright (CHC); Severn (JHM). VICTORIA: Rosedale, Balsam L. (PH); Bobcaygeon (JHM). PETERBOROUGH: Lovesick L. LEEDS: Lyn (FPI). CARLETON: Ottawa (Hagen '75); Mississippi R. near Galetta and near Pakenham. MUSKOKA: Go Home Bay; Kahshe R. PARRY SOUND: Mississauga R. (PH); Burke's Falls (FPI); Sand Crk., Frank's Bay, L. Nipissing. RENFREW: Heeney Crk. NIPISSING: Goose Is., Manitou I. and islands near headwaters of French R., L. Nipissing; L. Traverse (JRD), Joe L. and Oxtongue R., Algonquin Park. THUNDER BAY: South Bay, L. Nipigon; Silver I., L. Superior (DAM). KENORA: Minaki.

Common about the larger rocky streams and lakes, especially in the Pre-Cambrian regions south of the Hudson Bay watershed, rare in calcareous regions. The dates range from June 16 to Aug. 20 (Go Home Bay). Emergence usually begins about the third week in June and is over early in July, the adults flying until after the middle of August.

62. **Ophiogomphus colubrinus** Selys

RENFREW: Portage du Fort, Ottawa R. (FPI). MANITOULIN: Killarney. NIPISSING: Nipissing R., Algonquin Park (FPI). THUNDER BAY: Nipigon R. at Nipigon; Orient Bay, Grand Bay, Wabinosh and Bear R., L. Nipigon; Gull R. (CSH); Silver I., L. Superior. COCHRANE: Smoky Falls, Mattagami R. (RVW); Mattagami R. below rapids (WJKH); Moose R. crossing, T. & N. O. Ry. (WJKH). KENORA, Patricia section: Favourable L. region; Fort Severn (CEH).

Clear, rapid streams in the Canadian and Hudsonian zones; the most northern gomphid. The dates range from June 17 to Sept. 3. All the individuals (4♂, 4♀) from the Severn River at Fort Severn were newly emerged or teneral and were taken on July 9 and 15.

63. **Ophiogromphus carolus** Needham

DUFFERIN: Horning's Mills (FPI). SIMCOE: Nottawasaga R., 1 mile s. of Alliston. ALGOMA: Heyden and Searchmont, on tributaries of the Goulais R. (EBW).

Clear rapid streams, Alleghanian. The dates range from June 11 (Nottawasaga R.) to Aug. 8 (Searchmont).

64. **Ophiogomphus rupinsulensis** (Walsh)

KENT: Thames R., Orford twp. WATERLOO: Grand R., Galt (NF). HALTON; Bronte Crk. (JGO). PEEL: Credit R. at Meadowvale and Erindale. YORK: Humber R. at Kleinburg, Mount Dennis and near Toronto. HASTINGS: Belleville (JDE). MUSKOKA: Goose L. near Dorset (JGO). PARRY SOUND: Shawanaga R. (PH). NIPISSING: Oxtongue R., Algonquin Park. THUNDER BAY: Orient Bay, L. Nipigon. COCHRANE: Smoky Falls, Mattagami R. (RVW).

Generally distributed, breeding in more or less rapid streams in various types of soil, more tolerant of silt than the other species of *Ophiogomphus*. The dates range from May 31 (Kleinburg) to Sept. 23 (Smoky Falls). In the southern counties the season of flight is apparently over before August.

65. **Ophiogomphus anomalus** Harvey

PARRY SOUND: Shawanaga R. RENFREW: Ottawa R. at Pembroke, 21.VI. '36, exuviae. THUNDER BAY: Oliver Crk., Slate R. valley; Three-mile Rapids, Gull R., west side of L. Nipigon, 10. VI. '22,* emerging.

Clear rapid streams and large rivers, Alleghanian and Canadian zones, very local. The earliest date is June 10 (Gull R.) and the latest July 10, but there are not enough records to indicate the length of the adult season.

66. **Lanthus albistylus** (Hagen)

NIPISSING: Oxtongue R., Algonquin Park; L. Timagami (AWAB). ALGOMA: Heyden and Searchmont (EBW).

Shallow rapids with projecting stones, in clear streams, probably of general occurrence on the Pre-Cambrian region, in the Alleghanian and southern part of the Canadian zone. The range of dates, July 28 to Aug. 14 (both in Algonquin Park) is insufficient to indicate the length of the season of adult life. It was found emerging on June 21 on a tributary of the Gatineau River, Quebec, and it doubtless emerges about this time also in Ontario.

67. **Gomphus villosipes** Selys

WELLAND: Niagara Glen (GSW); Chippawa; Welland R. near Hewitt. PEEL: Credit R. at Erindale. YORK: Don valley, Toronto. SIMCOE: Gilford, Cook Bay, L. Simcoe.

Quiet, muddy streams; Carolinian into Alleghanian. The dates range from June 11 to July 24. Numerous exuviae were found on June 11, 1933, at the Gilford stream but the adults were already fully mature and flying along the stream. It is evident, therefore, that emergence must take place considerably earlier than this date.

68. **Gomphus furcifer** Hagen

ESSEX: Pt. Pelee. KENT: Rondeau Park. NORFOLK: St. Williams; Long Point; Turkey Point (WJB). BRANT: Dumfries S. twp. WENTWORTH: Valley Inn Crk., Hamilton (col.?). PEEL: Gibson L. YORK: Toronto; Kelly L. PRINCE EDWARD: Picton (NF). SIMCOE: Cook Bay, L. Simcoe. LEEDS: Gananoque R., near Gananoque; Lyn (CHC). CARLETON: Leonard. MUSKOKA: Go Home Bay.

*Incorrectly reported as July 10, '22 (Walker '24).

Marshy lakes and slow, weedy streams; very abundant at Point Pelee, Grenadier Pond (Toronto) and DeGrassi Point, rare northward, only a single exuvia having been found at Go Home Bay; Carolinian and Alleghanian. The adult season is early, the recorded dates ranging from May 20 to July 27 (both at DeGrassi Pt.). Emergence has been observed up to June 8. By about June 20 or earlier they have all returned from their wanderings and are seen in large numbers about the broad, pond-like mouth of the stream, where they rest on the lilypads.

69. **Gomphus cornutus** Tough

ONTARIO: Uxbridge 1 ♂ (RGHC). LEEDS: Brockville, 27.VI.'29, 3 ♂. CARLETON: Castor R., Carlsbad Springs (Ent. Rec. '17). KENORA: Minaki, 4.10.VII.'28 (JHM); 21.VII.'31, 2 ♀.

Slow, muddy streams and swampy lakes, very local in Ontario. The only locality where it has been taken in numbers is the Castor River at Carlsbad Springs.

70. **Gomphus spicatus** Hagen

ESSEX: Pt. Pelee (GSW). KENT: Arran L. (GSW); Big Point, L. St. Clair, and Rondeau Park (SL & WL). NORFOLK: Long Point. WENTWORTH: Hamilton. WATERLOO: near Galt (NF). PEEL: Snelgrove (JW). YORK: Bond L.; Wilcox L.; Kelly L. PETERBOROUGH: Stony L. (JGO). PRINCE EDWARD: Sand Hills; East L. BRUCE: Johnson's Harbour (WL); Millar L. (JGO); Red Bay (NF). SIMCOE: Cook Bay, L. Simcoe; Orillia and Severn (JHM). VICTORIA: Bobcaygeon (JHM). HASTINGS: Belleville. FRONTENAC: Silver L. LANARK: Fall R. CARLETON: MacKay's L., Rockcliffe (JHM). MUSKOKA: Go Home Bay; Giant's Tomb I., Geo. Bay; Black L., L. of Bays (JHM). PARRY SOUND: Kearney (FPI); Frank's Bay, L. Nipissing. RENFREW: Petawawa Reserve (VEH). NIPISSING: Madawaska R., Algonquin Park (JHM); near headwaters of French R. THUNDER BAY: Black Sturgeon L.; Gull Bay, L. Nipigon (NKB); Silver I., L. Superior; Burnt I., L. Superior (DAM). COCHRANE: Cochrane (FJ). KENORA: Ingolf (WND); Minaki (JHM).

Boggy lakes and ponds, and weedy bays; generally distributed and abundant south of the Hudson Bay watershed, reaching its largest size at Minaki. The season of adult is early, the dates ranging from May 24 (Kelly L.) to July 31 (Bruce Co.). The latter is an unusually late date; throughout most of its range the season is over by the middle of July. Nevertheless, at Gull Lake, near its northern boundary, a nymph was taken in transformation on July 23.

71. **Gomphus quadricolor** Walsh

PEEL: Credit R. at Erindale.

The adults fly over gentle rapids and probably oviposit here, but the full-grown nymphs are found in quieter water below the rapids and

it is here that emerges takes place. The dates range from June 7 to July 2, but emergence may begin a little earlier than the former date.

72. **Gomphus exilis** Selys

WATERLOO: Dumfries N. twp. PEEL: Credit R. near Inglewood. YORK: Toronto; Wilcox L. PRINCE EDWARD: Picton (NF). SIMCOE: Cook Bay, L. Simcoe. HASTINGS: Moira R. near Belleville. FRONTENAC: near Kaladar. LEEDS: Gananoque R. near Gananoque; Brockville; Lyn (FPI, GSW). LANARK: Innisville; Perth. PRESCOTT: Plantagenet. CARLETON: Ottawa; MacKay's L., Rockcliffe (AWR); Mississippi R. near Galetta and near Pakenham. MUSKOKA: Go Home Bay; Black L., L. of Bays (JHM); Port Sydney (RY). PARRY SOUND: Frank's Bay, L. Nipissing. RENFREW: Barbut Crk. NIPISSING: near headwaters of French R.; Sandy I. and various stations on L. Nipissing; Vaase R., outlet of L. Nipissing (JGO); Algonquin Park; Smooth Water L., Timagami (JF); Deer Bay, L. Timagami (JGO). THUNDER BAY: Orient Bay and Shakespeare I., L. Nipigon; Silver I., L. Superior.

Quiet streams with a soft bottom and shallow, marsh-bordered lakes, abundant and generally distributed south of the Hudson Bay watershed and probably occurring somewhat farther north. The records range from June 14 to Aug. 12. Emergence or newly emerged individuals have been noted from June 19 to 27 (Go Home Bay, Picton and Shakespeare Island).

73. **Gomphus lividus** Selys

HALDIMAND: Oneida twp. YORK: Humber R. at Kleinburg. SIMCOE: Nottawasaga R. near Alliston; Cook Bay, L. Simcoe; Orillia (JHM); Severn (JHM, CHC). VICTORIA: Bobcaygeon (JHM). FRONTENAC: Arden. MUSKOKA: Go Home Bay; Kahshe R.; L. of Bays; Port Sydney (RY). PARRY SOUND: Kearney (FPI); Sand Crk. and Frank's Bay, L. Nipissing; Shawanaga R. NIPISSING: islands in L. Nipissing near headwaters of French R.; Joe and Burnt Island L., Algonquin Park; Earl L., Mattawa; L. Timagami (JGO); Kokokosing L. (JF). ALGOMA: Heyden (EBW). THUNDER BAY: L. Nipigon, nymphs in stomachs of sturgeon; Gull R. (CSH).

Gently flowing streams and rocky lakes in slightly more exposed situations than *G. exilis*, although their habitats overlap widely; often very abundant but short-lived in the adult state. The distribution in Ontario is similar to that of *G. exilis*, but *G. lividus* is more local in the southern counties by reason of its habitat. The dates range from May 25 (DeGrassi Pt.) to July 31.

74. **Gomphus descriptus** Banks

WELLINGTON: Guelph (col.?). SIMCOE: Nottawasaga R., s. of Alliston. PARRY SOUND: Island L., Kearney (FPI). NIPISSING: Madawaska R. (JHM), and Costello L., Algonquin Park (RBM).

Clear, more or less rapid streams, Alleghanian. McDunnough states that this species was the most abundant Gomphus on the Madawaska River. It appears to be local in Ontario but has perhaps been overlooked. The dates range from June 4 (Nottawasaga R.) to July 30, but the season undoubtedly begins somewhat earlier, probably before the end of May.

75. **Gomphus borealis** Needham

NIPISSING: Costello L., Algonquin Park, 24.VI.'38, 2♂ (RBM).

An Alleghanian species, which appears to have entered Quebec from the Adirondacks of New York State.

76. **Gomphus graslinellus** Walsh

LAMBTON: Walpole I., R. St. Clair, 14.VIII.'35. KENORA: Minaki, 6-10.VII.'28 (JHM), 23.VII.'31.

Lakes and rivers, extremely local in Ontario but transcontinental in the United States and occurring also in Manitoba and British Columbia. The season was evidently nearly over at Lambton where very few individuals were seen and only one damaged male was taken. At Minaki, on July 23, the season was also nearly over. A small number of individuals, nearly all females, were flying over a broad, sandy beach in a small rockbound bay on the Winnipeg River.

77. **Gomphus brevis** Hagen

SIMCOE: Severn (JHM). LANARK: Innisville. CARLETON: Ottawa; MacKay's L., Rockcliffe (JHM). MUSKOKA: Go Home Bay and River. PARRY SOUND: Sand Crk., Frank's Bay, L. Nipissing. NIPISSING: Mattawa (CEA); Goose Is., L. Nipissing; L. Traverse (JRD), Madawaska R. (JHM) and Oxtongue R., Algonquin Park. ALGOMA: Silver Crk. valley, near Sault Ste. Marie (col.?). THUNDER BAY: Orient Bay and Wabinosh, L. Nipigon; Slate River valley. COCHRANE: Abitibi L. region (Dr. Cook, possibly in Quebec).

Rapid, rocky streams, often below falls; Alleghanian and Canadian. The dates range from June 15 (Go Home Bay) to Aug. 20 (Algonquin Park). Emergence at Go Home Bay was observed from June 15 to 23.

78. **Gomphus viridifrons** Hine

KENT: Bothwell, 23.V.'25, 1♀ (GSW).

From a tributary of the Thames River.

79. **Gomphus fraternus** (Say)

ESSEX: Pt. Pelee. KENT: Rondeau Park; Chatham; Thames R., Orford twp.; Bothwell (GSW). ELGIN: Fisher's Glen (GSW). NORFOLK: St. Williams; Long Pt.; Turkey Pt. (GSW); Norfolk (TNF). WELLAND: Niagara Glen. PEEL: Credit

R., Erindale. YORK: Humber R. at Kleinburg. SIMCOE: Sand I., L. Simcoe (DSR), Orillia (JHM); Victoria Harbour. KENORA: Norman; Minaki.

Rivers and shallow bays of large lakes with emergent vegetation; abundant in Lake Erie, apparently absent from the Pre-Cambrian region, except in the extreme west, where it occurs in a large and robust form. The dates range from May 31 (Kleinburg) to July 23 (Minaki). Emergence takes place chiefly during June.

80. **Gomphus vastus** Walsh

ESSEX: Pelee I. (FMR, NF, WJB). PRESCOTT: Ottawa R. near Point Fortune, Que. CARLETON: Ottawa (GB); Mer Bleue (FPI). RENFREW: Marshall's Bay, Arnprior (CGH).

Large rivers and lakes. It will doubtless be found on the St. Lawrence in Ontario, since it occurs on this river in Quebec. Our records are insufficient to indicate the length of the adult season. Numerous adults observed in Prescott Co. on June 23 were all teneral, some just emerged.

81. **Gomphus ventricosus** Walsh

CARLETON: Ottawa, VII.'24, 1♂ (ALP).

This rare species has been taken elsewhere in Canada only in the vicinity of Fredericton, N.B., and Farnham, Que.

82. **Gomphus scudderi** Selys*

PEEL: Credit Forks (FPI). YORK: Toronto. BRUCE: Stoke's Bay (NF). CARLETON: Brittania Bay (JGO). MUSKOKA: L. Muskoka (WSG?); Port Sydney (NKB); Norway Pt., L. of Bays (JHM). PARRY SOUND: Mississauga R.; Blind R. (PH); Sand Crk., Frank's Bay, L. Nipissing. RENFREW: Big Tucker Crk. (JGO). NIPISSING: Madawaska R. (JHM), Nipissing R. (FPI), L. Traverse (JRD) and Oxtongue R., Algonquin Park; Wakimaka Crk., Timagami. ALGOMA: Goulais R. and tributaries at Searchmont (EBW).

On the larger forest streams where there is a gentle current, common in the streams of the Pre-Cambrian region of southern Ontario; mainly Alleghanian. It is a late species, the dates ranging from June 25 (Britania Bay, exuv.) to Sept. 9 (Timagami). Emergence has been observed by Dr. Ide at Credit Forks as late as Aug. 28, 1928.

83. **Gomphus plagiatus** Selys

ESSEX: Pelee I., 19.VII. '24, 1 exuv. (NF).

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*I have recently (Walker '33, '34) followed Williamson in giving generic rank to the Stylurus group of Gomphus to which this and the remaining species listed here belong. I now believe, however, that thorough revision of the entire genus should be undertaken before it is subdivided.

This exuvia undoubtedly belongs to *G. plagiatus* and not *notatus*. Pelee Island is probably the only station for this species in Canada. It is known to occur on the islands to the immediate south of Pelee and at Put-in Bay, Ohio (Kennedy '22).

84. **Gomphus notatus** Rambur

KENT: Johnson's Pt., Johnson R. LAMBTON: Walpole I. and Courtright, St. Clair R. CARLETON: Mer Bleue (JHM). NIPISSING: L. Nipissing (JRD). TIMISKAMING: L. Timiskaming. THUNDER BAY: Gull L.; Gull R. at L. Nipigon, nymphs in stomachs of sturgeon and suckers (Walker, '24, reported at *G. scudderi*). KENORA: Minaki. RAINY RIVER: Manitou rapids, Rainy R. (Rainy River Investigation, 1937).

Large rivers and lakes, widely distributed but local. Individuals reared or found in transformation were taken on July 7 (L. Timiskaming), July 21 and 22 (Minaki), July 23 (Gull L.) and Aug. 14 (Walpole Island and Courtright). It thus matures late, apparently later in southern than in northern localities, but we have no data on the length of adult life.

85. **Gomphus spiniceps** (Walsh)

RENFREW: Treadwell, 17.IX.'28, 1 exuv. (FPI); Petawawa Forest Reserve, 30.VI.'35 (VEH).

This is another late species of large rivers, known in Canada only from the Ottawa River and its tributaries, the Petawawa and Gatineau Rivers. The single record from the Petawawa Reserve is that of an individual taken during emergence. It is probably an unusually early one.

86. **Dromogomphus spinosus** Selys

KENT: Thames R. at Chatham and in Orford twp.; Bothwell (GSW). YORK: Toronto. SIMCOE: Cook Bay, L. Simcoe; Orillia and Severn (JHM). HASTINGS: Moira R. near Belleville (JGO). LEEDS: Lyn (GSW, CHC). PRESCOTT: Nation R., Plantagenet. CARLETON: Rideau R., Ottawa South (JHM); Carp (CHY); Mississippi R. near Galetta and near Pakenham. MUSKOKA: Go Home Bay; Bala; Port Sydney (RY). PARRY SOUND: Mississauga R.; Shawanaga. MANITOULIN: Mindemoya L. (TBK). NIPISSING: Cache L. (JHM) and Costello L. (RBM), Algonquin Park. ALGOMA: Thessalon.

Large, somewhat rapid streams or lake shores, common throughout southern Ontario. The dates range from June 5 to Sept. 17, but it usually emerges in late June or early July and is common throughout August.

CORDULEGASTERIDAE

87. **Cordulegaster maculatus** Selys

ESSEX: Pt. Pelee (GSW). KENT: Bothwell (GSW). NORFOLK: Simcoe (TNF). WATERLOO: Dumfries N. twp. YORK: Holland R. near Vandorff. DUFFERIN: Horning's Mills (FPI). SIMCOE: Cook Bay, L. Simcoe; Orillia (JHM, CHC). MUSKOKA: Port Sydney. PARRY SOUND: Sand Crk., Frank's Bay and South Bay, L. Nipissing. NIPISSING: Madawaska R. (JHM), L. Traverse (JRD) and Joe L., Algonquin Park. ALGOMA: Stony Crk. and Little Carp R. (col.?). SUDBURY: Sudbury (JDE). THUNDER BAY: White Sand (NKB), Orient Bay, Fraser Crk. and Alexander Portage, L. Nipigon; Gull R. (CSH); Silver I., L. Superior. COCHRANE: Lowbush and Long Pt., L. Abitibi.

Forest streams, developing in pools below gentle rapids; generally distributed and very common in uncleared areas. Emergence begins late in May. Dates of capture at Lake Simcoe range from May 29 to July 12, but in the north the season is later, the latest date being July 24 (L. Nipigon).

88. **Cordulegaster obliquus** (Say)

WENTWORTH: Waterdown (LZ). CARLETON: Blackburn (JHM).

A very rare species of more southern distribution than the other two Cordulegasters.

89. **Cordulegaster diastatops** (Selys)

PEEL: Credit Forks. YORK: Summerville; Holland R. near Vandorff. ONTARIO: Glen Major (WER). SIMCOE: Cook Bay, L. Simcoe; Churchill; Stroud; Orillia (CHC). MUSKOKA: Port Sydney. NIPISSING: Cache L., Algonquin Park (JHM). ALGOMA: vicinity of Silver Falls (col.?).

Small brooks and spring runs, usually in more open places than *C. maculatus;* doubtless much more widely distributed than the above records indicate. Adults have been observed at Lake Simcoe from May 25 to July 4. Our latest date is July 19 (Credit Forks).

CORDULIIDAE

90. **Cordulia shurtleffi** Scudder

PEEL: Dufferin L. near Credit Forks. YORK: Kelly L. DUFFERIN: Horning's Mills (FPI). SIMCOE: Cook Bay, L. Simcoe; Singhampton (WER); Midland (RPW); Severn (JHM). VICTORIA: Fenelon Falls (WER). CARLETON: Ottawa (JHM); Constance Bay (WJB). HALIBURTON: Rackety R., Gull L. (PH); Miner's Bay, Gull L. (FPI). MUSKOKA: Go Home Bay and River; Norway Pt., L. of Bays (JHM). PARRY SOUND: Kearney (FPI). RENFREW: Petawawa Forest Reserve (VEH). MANITOULIN: Killarney (FPI). NIPISSING: Tern Rock, L. Nipissing; Algonquin

Park (JHM, RHO); Joe and Burnt Island L., Algonquin Park; L. Timagami (AWAB). ALGOMA: Stony L. (EBW); Silver Creek falls, Sault Ste. Marie (col.?). SUDBURY: Sudbury; Gogama (JKM). THUNDER BAY: Nipigon; Orient Bay and small lakes near Macdiarmid, L. Nipigon; Gull R. (CSH); Silver I., L. Superior. COCHRANE: Long Pt., Lowbush and Ghost R., L. Abitibi; Smoky Falls, Mattagami R. (GSW). KENORA, Patricia division: Hawk L. (HCL); Favourable Lake region; Attawapiskat L.

Marshy or bog-margined lakes, ponds and slow streams, generally distributed and abundant in the Canadian zone, local in the Transition, where it is restricted to sphagnum ponds or lakes. It is an early species, the dates ranging from May 24 (Gull Lake) to Aug. 3 (Stony L.). The latter date, however, is the only one for August, the principal season of flight being in June and early July. Very young individuals were taken in the Favourable Lake region on June 2 and 3, numerous adults throughout June and none after July 6.

91. **Dorocordulia libera** (Selys)

ESSEX: Pt. Pelee. WATERLOO: Dumfries N. twp. YORK: Bond L. SIMCOE: Cook Bay, L. Simcoe; Severn (JHM). VICTORIA: Fenelon Falls (WER); Bobcaygeon (JHM). CARLETON: Ottawa (CHY); Rockcliffe (GHF); Blackburn (RHO). MUSKOKA: Go Home Bay; Port Sydney; Deer L. PARRY SOUND: Sand Crk., Frank's Bay, L. Nipissing. NIPISSING: Goose Is. and Blueberry I., L Nipissing; headwaters of French R.; Cache L. (JHM) and Joe L., Algonquin Park. ALGOMA: Stony L. (EBW). THUNDER BAY: near Longuelac; Orient Bay, L. Nipigon; Fort William. KENORA: Minaki.

Marsh-bordered lakes and slow boggy streams, fairly common and generally distributed south of the Hudson Bay watershed. The dates range from June 1 (Severn) to Aug. 3 (Stony Lake), emergence taking place chiefly during the second half of June.

92. **Somatochlora walshii** (Scudder)

BRANT: Glen Morris (NF). WELLINGTON: Guelph (RHO). PEEL: Credit Forks. YORK: Toronto; Schomberg. ONTARIO: Glen Major (FPI, WER). PRINCE EDWARD: Hillier (GS). BRUCE: Southampton (GSW). SIMCOE: Cook Bay, L. Simcoe; Churchill; Stroud. HASTINGS: Tweed (ESS). CARLETON: Mer Bleue. MUSKOKA: Bracebridge. NIPISSING: Island Bay Crk. (WER) and Ko-ko-ko L., Timagami. THUNDER BAY: Orient Bay, L. Nipigon. COCHRANE: Lowbush, L. Abitibi.

Small, quiet streams or ditches in boggy places, spring-fed streams preferred; generally distributed and not infrequent in its special habitat. The earliest and latest dates are June 3 (Mer Bleue) and Aug. 13 (Glen Major). The main season of flight seems everywhere to be in July.

93. **Somatochlora minor** Calvert

SIMCOE: Cook Bay, L. Simcoe; Singhampton (FPI, WER). CARLETON: Blackburn (JHM). MUSKOKA: Bracebridge. PARRY SOUND: Sand Crk., Frank's

Bay, L. Nipissing. NIPISSING: Algonquin Park (JHM); near Joe L., Alg. Park. ALGOMA: Sault Ste. Marie, Silver Falls and Little Carp R. (col.?). THUNDER BAY: near Longuelac; Orient Bay, L. Nipigon; Oliver Crk., Slate River valley; Gull R.; Fort William; Silver I., L. Superior. COCHRANE: Lowbush and Upper Lake, L. Abitibi; Smoky Falls, Mattagami R. (GSW). KENORA, Patricia division: Favourable L. region; Attawapiskat L.

Small, gently flowing forest streams; Canadian into Hudsonian but occurring locally in the Transition zone; common northward. At its southern limit, near DeGrassi Point, where it is not uncommon on a small stream, the adult season ranges from early June to the beginning of August, the earliest date being June 6 and the latest Aug. 5. Elsewhere the earliest date is June 10, when a specimen was found emerging on the Gull River, Lake Nipigon.

94. **Somatochlora elongata** (Scudder)

PARRY SOUND: Sand Crk., Frank's Bay, L. Nipissing. NIPISSING: Algonquin Park (JHM); Costello L. (RBM), Smoke L. and Oxtongue R., Algonquin Park; stream near north end of L. Timagami; Island Bay Crk., Deer Bay and Outlet Bays, L. Timagami (WER). ALGOMA: Heyden (EBW). THUNDER BAY: Orient Bay, L. Nipigon.

Forest streams with a decided current, locally common in the Canadian zone and doubtless distributed farther north than the records indicate. The dates, which are scanty, range from June 20 to Aug. 24. Most of the records are for the month of August.

95. **Somatochlora williamsoni** Walker

BRANT: Glen Morris (MP). WELLINGTON: Guelph (NB). YORK: Toronto; Maskinonge R. DUFFERIN: Horning's Mills (FPI). BRUCE: Johnson's Harbour (WL); Southampton (GSW). SIMCOE: Cook Bay, L. Simcoe, Washago. MUSKOKA: Go Home Bay; Port Sydney (NKB); Norway Pt., L. of Bays. PARRY SOUND: Sand Crk., Frank's Bay, L. Nipissing; Kearney (FPI). MANITOULIN: Fitzwilliam I., Georgian Bay. NIPISSING: Goose Is., L. Nipissing; French R. near headwaters; Tomico R. and Mud L., near North Bay (WER); Oxtongue R., Godda, Crown and Wolf L. (FPI), Costello L. (RBM) and Joe L., Algonquin Park; Deer Bay, High Rock I. and Outlet Bay, L. Timagami (WER); Obabika L., Cross L. and Ko-ko-ko L., Timagami. ALGOMA: Root R. THUNDER BAY: Shakespeare I. (OFRL), Orient Bay and Wabinosh, L. Nipigon; Current E.; Gull R. (CSH); Pelican L.; Silver I., L. Superior. COCHRANE: Lowbush R., L. Abitibi.

Quiet, shady, forest streams; common in the lower Canadian and northern parts of the Transition zone, but females are very secretive and are seldom seen. It is the commonest Somatochlora except in the far north. The dates range from June 27 to Sept. 14, both from DeGrassi Point, where a long series of records has been obtained. It is common throughout July and August.

96. Somatochlora tenebrosa (Say)

NORFOLK: Simcoe (GMF). WENTWORTH: Hamilton(?). WELLINGTON: Guelph (OEY). HALTON: Limehouse (Medcalf). ONTARIO: Glen Major (WER). SIMCOE: Cook Bay, L. Simcoe. NIPISSING: Godda L., Algonquin Park (FPI); Gull Lake Torrent, Timagami (WER).

Shady forest streams; mainly Alleghanian and Carolinian, but occurring locally in the lower Canadian zone, rare in Ontario. The earliest and latest dates are July 1 and August 29, both from DeGrassi Pt. The specimens from Timagami (4♂, 1♀) were taken on Aug. 24, 1931.

97. Somatochlora franklini (Selys)

SIMCOE: DeGrassi Pt. (Cook Bay), 3.VI.'34, 1♂. CARLETON: Mer Bleue. THUNDER BAY: Sucker R. near Longuelac; Black Sturgeon L. COCHRANE: Smoky Falls, Mattagami R. (RVW); Moosonee; Nettitichi Pt., James Bay, 14.VII.'34 (ESP). KENORA, Patricia division: Favourable L. region; Attawapiskat L.; Fort Severn, Hudson Bay (CEH).

Cold sphagnum bogs, Hudsonian and cooler parts of the Canadian zone, common north of the Hudson Bay watershed. An isolated population occurs in the Mer Bleue, an extensive peat bog far south of its general range, and here it has been taken from May 20 to July 1. The season is later in the far north, specimens from James Bay taken on July 14 being all quite young. The specimens from the Patricia region, taken from June 22 to July 20, are also chiefly juveniles. The latest date is that of the single specimen from Black Sturgeon Lake, July 20. The individual from DeGrassi Point was undoubtedly a straggler.

98. Somatochlora kennedyi Walker

YORK: near Schomberg. SIMCOE: Cook Bay, L. Simcoe; Severn (JHM). CARLETON: Mer Bleue. HALIBURTON: Miner's Bay (JHM). MUSKOKA: Port Sydney. PARRY SOUND: Frank's Bay, L. Nipissing. NIPISSING: Ko-ko-ko L., Timagami. ALGOMA: Sault Ste. Marie. COCHRANE: Lowbush, L. Abitibi; Smoky Falls, Mattagami R. (RVW).

Cold bogs and swamps, typical of the Canadian zone but occurring also locally in the Transition zone. It is an early species, at least in Southern Ontario, the season of flight coinciding approximately with the month of June. The earliest and latest dates from the Mer Bleue are June 5 and July 1. The latest date elsewhere in the Province is Aug. 5 (Timagami).

99. Somatochlora incurvata Walker

PARRY SOUND: Sand Crk., Frank's Bay, L. Nipissing, 21.VII. '29, 1♂.

The only other localities known for this species are Whitefish Point, Chippewa Co., Mich.; Truro, N.S.; White Point Beach, Queen's Co., N.S. (JHM) and the Moser River, Halifax Co., N.S., where a male was taken between October 10 and 15, by Mr. H. C. White. This is an extraordinarily late date for a Somatochlora.

100. **Somatochlora forcipata** (Scudder)

SIMCOE: Cook Bay, L. Simcoe. NIPISSING: Algonquin Park; Long Gull Lake portage, Timagami, 2♂ (WER). COCHRANE: Smoky Falls, Mattagami R. (RVW).

Small, spring-fed, boggy streams; boreal, ranging through the Canadian into the Hudsonian zone, rare and local in the Transition but probably not uncommon in the north, in spite of the few records. The range of dates is from June 26 (Lake Simcoe) to Aug. 17 (Timagami).

101. **Somatochlora whitehousei** Walker

KENORA, Patricia section: Fort Severn, Hudson Bay, 4-20 VII. '40, 36♂, 56♀ (CEH & WBS).

Cold bogs or muskegs in the Hudsonian zone, from Labrador to British Columbia. Judging from the large series taken at Fort Severn, this must have been one of the most abundant dragonflies in the district.

102. **Somatochlora septentrionalis** (Hagen)

KENORA, Patricia section: Fort Severn, Hudson Bay, 20, 21. VII. '40, 2♀ (CEH).

Cold bogs in the Hudsonian zone, from Labrador and Newfoundland to northern British Columbia. In Labrador it is more abundant than *S. whitehousei*, but on Hudson Bay the reverse is the case.

103. **Somatochlora albicincta** (Burm.)

THUNDER BAY: Nipigon; Orient Bay, Virgin Isles, Cook Pt. and Black Sturgeon Bay, L. Nipigon, and the north end of L. Nipigon. COCHRANE: Lowbush, L. Abitibi; Smoky Falls, Mattagami R. (GSW). KENORA, Patricia section: Attawapiskat L.; Fort Severn, Hudson Bay (CEH).

Quiet, bog-margined streams and open bog ponds, strictly boreal; common in the upper Canadian and Hudsonian zones. The dates range from July 14 to Sept. 1.

104. **Somatochlora hudsonica** (Hagen)

THUNDER BAY: Sucker R. COCHRANE: Moose Factory. KENORA, Patricia section: Favourable Lake region; Attawapiskat L.; Fort Severn, Hudson Bay (CEH).

These are the only records of this Hudsonian species east of Manitoba. Its haunts are similar to those of *S. albicincta*. The dates range from June 27 (Favourable Lake) to Sept. 28 (Moose Factory).

105. **Somatochlora cingulata** (Selys)

NIPISSING: Island Bay and near High Rock, L. Timagami (WER). THUNDER BAY: headwaters of Sucker R.; Longuelac; Grassy L.; Silver I. and St. Ignace I., L. Superior. COCHRANE: Sucker L. near L. Abitibi; Hurricanaw I., Hannah Bay, James Bay, 14.VII.1934, 1♂ (ESP); Smoky Falls, Mattagami R., full-grown nymph in stomach of pike (RVW). KENORA, Patricia section: Favourable L. region; Attawapiskat L.

Lakes and large streams; Canadian and Hudsonian zones, ranging somewhat farther south than *S. albicincta*. The dates range from June 24 to Sept. 5. A large series taken at Attawapiskat Lake, June 24-26, were all more or less teneral.

106. **Williamsonia fletcheri** Wmsn.

CARLETON: Mer Bleue. NIPISSING: L. Timagami, 11.VI.1932, 1♂ (AWAB).

A glacial relict inhabiting muskegs and possibly widely distributed in the north. Its season at Mer Bleue is very early and brief, doubtless sometimes earlier than is suggested by the dates, which range from May 19 to June 5. This is indicated by the fact that specimens taken in May 19, 1911, by Dr. F. P. Ide and Prof. J. S. Rogers are all mature and include a pair taken in coitu.

107. **Helocordulia uhleri** (Selys).

WELLINGTON: Guelph (col.?). HASTINGS: Black R. FRONTENAC: Salmon R. MUSKOKA: Go Home Bay; Port Sydney (NKB). PARRY SOUND: Magnetawan R. (PH); Shawanaga R.; French R. near headwaters; Sand Crk., Frank's Bay, L. Nipissing. RENFREW: Petawawa Forest Res. (VEH). NIPISSING: Smoke L. and Joe L., Algonquin Park; L. Timagami (AWAB). THUNDER BAY: Orient Bay, L. Nipigon.

Rocky streams and lakes, not uncommon in the Alleghanian and southern parts of the Canadian zone. The season of flight is early, the dates ranging from May 25 (Magnetawan River) to July 14 (L. Nipigon). Specimens taken on the Magnetawan on May 25 were all teneral.

108. **Tetragoneuria canis** McLachlan

DUFFERIN: Horning's Mills (FPI). SIMCOE: Cook Bay, L. Simcoe; Singhampton (WER). VICTORIA: Bobcaygeon (JHM). PETERBOROUGH: Havelock. LANARK: Silver L.; Innisville. LEEDS: Brockville. CARLETON: Ottawa; Mer Bleue and Carlsbad Springs (JHM). HALIBURTON: Minden (GSW). PARRY SOUND: Frank's Bay, L. Nipissing (WER). RENFREW: Petawawa Forest Res. (VEH). NIPISSING: Sandy I., L. Nipissing; Cache L. (JHM), Joe L. and Burnt Island L., Algonquin Park. SUDBURY: Sudbury (JDE). COCHRANE: Lowbush and Ghost R., L. Abitibi. KENORA: Minaki (JHM).

Bog ponds and slow, boggy streams; Canadian and Transition zones. It is of regular and constant occurrence at the stream near DeGrassi

Point, whereas the other Tetragoneurias are very irregular in this locality, both in occurrence and in numbers. This is one of our earliest dragonflies to appear in the spring, emergence having been observed at DeGrassi Pt. from May 10 to June 16. The range of dates is from May 6 (Petawawa Res.) to July 18 (L. Abitibi).

109. **Tetragoneuria spinigera** Selys

YORK: Toronto; Pottageville; Kelly L.; Wilcox L.; Schomberg. BRUCE: Johnson's Harbour (WL). SIMCOE: Cook Bay, L. Simcoe; Nottawasaga R. near Alliston; Singhampton (WER); Severn (JHM). VICTORIA: Fenelon Falls (WER); Bobcaygeon (JHM). PETERBOROUGH: Madoc. LEEDS: Gananoque R. near Gananoque. LANARK: Silver L.; Innisville; Ashton; Carleton Place. GLENGARRY: Apple Hill (LMS). RUSSELL: near Clarence. CARLETON: Mer Bleue. MUSKOKA: Go Home Bay; Port Sydney (NKB). PARRY SOUND: Frank's Bay, L. Nipissing. RENFREW: White L., swarming. NIPISSING: islands in L. Nipissing; Joe L., Algonquin Park. SUDBURY: Sudbury. THUNDER BAY: Orient Bay, L. Nipigon; Shakespeare I., L. Nipigon (OFRL); Sand R.; Silver I., L. Superior; Burnt I., L. Superior (DAM); Fort William (AGH). COCHRANE: Smoky Falls, Mattagami R. (GSW). KENORA: Minaki (JHM); Hawk L., Patricia section (HCL).

Marshy borders of lakes and slow streams, abundant and generally distributed, especially in the Canadian zone. In the Transition zone, and perhaps elsewhere, it is subject to marked fluctuations in numbers. At DeGrassi Pt., e.g., it is sometimes absent for years in succession and then suddenly becomes abundant. The dates range from May 24 (Toronto) to July 15 (L. Nipissing). At Go Home Bay the season extended from May 29 to July 2.

In the region immediately north of Lake Superior this species appears of a uniformly larger size than elsewhere. In general, northern specimens are somewhat larger than southern, but the Lake Superior form appears to be a local race.

110. **Tetragoneuria cynosura cynosura** (Say)

ESSEX: Pt. Pelee. KENT: Rondeau Park. NORFOLK: Long Pt.; Fisher's Glen (GSW). HALDIMAND: Oneida twp. WELLAND: Chippawa. LINCOLN: Niagara-on-the-Lake; Jordan (GSW). PEEL: Credit Forks. YORK: Toronto. SIMCOE: Washago (CHC). HASTINGS: Belleville.

Marsh-bordered lakes, bays and mouths of slow streams with emergent vegetation, common and, in its typical form, practically confined to the Carolinian zone. The specimens from Credit Forks, Washago and Belleville approach the variety *simulans*, while at Toronto both varieties occur together with intergrades. The Credit Forks specimens were taken on July 19, all the others in June, the dates ranging from the 8th to the 27th. Our records, however, are scanty

and there is every reason to believe that emergence begins a week or so earlier than is indicated here.

110a. **Tetragoneuria cynosura simulans** Muttk.

ESSEX: Pt. Pelee (NKB). BRANT: Glen Morris (NF). YORK: Toronto; Bond L.; Wilcox L.; Kelly L.; Schomberg R. ONTARIO: Glen Major (WER). PRINCE EDWARD: Glen I., Picton (NF); Sand Hills; East L. BRUCE: Johnson's Harbour (WL). SIMCOE: Cook Bay, L. Simcoe. HASTINGS: Belleville; Black R. FRONTENAC: Arden; Silver L. LEEDS: Brockville; Portland (JHM); Lyn (GSW). LANARK: Fall R.; Perth; Innisville. PRESCOTT: Plantagenet. CARLETON: Ottawa; Mer Bleue. MUSKOKA: Go Home Bay; Norway Pt., L. of Bays (JHM); Port Sydney (NKB, RY). PARRY SOUND: Kearney (FPI). RENFREW: White L., swarming; Little Tucker Crk. NIPISSING: near headwaters of French R.; Costello L. (RBM) and Joe L., Algonquin Park; Timagami (ADR).

This form inhabits the same type of habitat as typical *cynosura* with which it sometimes intergrades. It appears to be rather characteristic of the Alleghanian zone but extends a short distance into the Canadian. Northern individuals, e.g., those from northern Muskoka and northward, show the maximum size of the dark patch at the base of the hind wings.

T. cynosura fluctuates considerably in numbers. It is sometimes extremely abundant, e.g., at Go Home Bay in 1907 and 1908. It has been at times abundant at DeGrassi Point but is sometimes absent or rare for periods of many years. The recorded dates range from May 30 (Wilcox L.) to July 3 (Go Home Bay). At Go Home Bay emergence was noted from June 13 to 17, being about two weeks later than that of *T. spinigera*, both at the beginning and end.

111. **Epicordulia princeps** (Hagen)

ESSEX: Pt. Pelee. KENT: Rondeau Park. ELGIN: Port Stanley. NORFOLK: St. Williams. WELLAND: Niagara Falls. WENTWORTH: Hamilton. PEEL: Erindale. YORK: Grenadier Pond, Toronto; Maskinonge R., L. Simcoe. PRINCE EDWARD: Sand Bay and West Lake. SIMCOE: Severn (JHM). PRESCOTT: Plantagenet. CARLETON: Ottawa district; Black Rapids, Rideau River (JHM); Mer Bleue (JAL); Mississippi R., near Galetta and near Pakenham. MUSKOKA: Go Home Bay. NIPISSING: Algonquin Park.

Rivers and lakes, in quiet waters, Carolinian and Transition zones; generally fairly common, especially southward. It has not been taken on Lake Simcoe and only one individual has been seen on the Maskinonge River. The dates range from June 7 (Erindale, a newly emerged ♀) to Aug. 5 (Go Home Bay).

Specimens from the Carolinian zone and as far north as Toronto have large nodal and apical spots. These spots decrease in size north-

ward, reaching their minimum at Go Home Bay, where the nodal spots may disappear altogether and only traces of the apical spots remain.

112. **Neurocordulia yamaskanensis** (Prov.)

ESSEX: Leamington, 27.VI.'34, 3 ♀. LANARK: Mississippi L. at Innisville. CARLETON: Ottawa. MUSKOKA: Go Home Bay; Port Sydney (RY). PARRY SOUND: Shawanaga R.; South Bay, L. Nipissing. NIPISSING: Ragged L., Algonquin Park; L. Timagami (JGO).

Rock-margined lakes and channels, apparently abundant in its special habitats, but seldom seen owing to its short season of flight and crepuscular habits. Most of the above records are based on exuviae. At Go Home Bay it emerged from June 23 to July 8 and the latest date on which it was observed was July 23. Exuviae, however, were found abundantly on the shore of Mississippi Lake, Lanark Co., on June 7, 1940.

113. **Didymops transversa** (Say)

NORFOLK: St. Williams. HALDIMAND: Oneida twp. SIMCOE: Cook Bay, L. Simcoe; Orillia (JHM); Severn (JHM). VICTORIA: Lower Mud Lake (LAP); Fenelon Falls (WER); Bobcaygeon (JHM). PETERBOROUGH: Stony L. (JGO). HASTINGS: Moira R. near Belleville; Black R. FRONTENAC: Arden. LANARK: Silver L.; Fall R.; Perth; Innisville. PRESCOTT: near Point Fortune, Que. CARLETON: Ottawa; Brittania Bay, Black Rapids, Rideau R. (FPI). MUSKOKA: Go Home Bay; Norway Pt., L. of Bays (JHM). PARRY SOUND: Shawanaga Bay (RPW); Kearney (PFI); Sand Crk., Frank's Bay, L. Nipissing. RENFREW: Petawawa Forest Res. (VEH). NIPISSING: L. Traverse (JRD), Joe and Blind Lakes, and Oxtongue R., Algonquin Park; L. Timagami (JGO). THUNDER BAY: Orient Bay, L. Nipigon; Silver I., L. Superior.

Forest lakes and larger streams, especially those with rocky shores, common and generally distributed in Southern Ontario. The season of flight is early, the dates ranging from May 23 (Mud Lake) to July 31 (Lake Simcoe), the latter date being exceptionally late. Emergence was observed at Go Home Bay up to June 19 .

114. **Macromia illinoiensis** Walsh

KENT: Thames R., Orford twp. MIDDLESEX: Thames R. near Wardsville. NORFOLK: Normandale (GSW). SIMCOE: Cook Bay, L. Simcoe. CARLETON: Dunrobin (HLV); Cyrville. MUSKOKA: Go Home Bay; Port Sydney (RY); Norway Pt., L. of Bays. PARRY SOUND: Sand Crk., Frank's Bay, L. Nipissing. MANITOULIN: Mindemoya L. (TBK). RENFREW: Petawawa Forest Res. (VEH). NIPISSING: Goose Is., L. Nipissing; Oxtongue R., Algonquin Park; North Bay (WER). THUNDER BAY: Wabinosh, L. Nipigon; Gull R. (CSH). KENORA: Minaki (JHM).

Rivers and large lakes with rocky shores, in more exposed situations than *D. transversa;* abundant on Georgian Bay, rarer northward and

not known beyond the Hudson Bay watershed. The dates range from June 17 (Petawawa River, 1 ♀ with exuv.) to Aug. 27 (DeGrassi Pt.). It usually emerges from about the end of June to the first week in July. In recent years it has been rare at DeGrassi Point, where it was formerly common, although no perceptible change in its habitat has taken place.

LIBELLULIDAE

115. **Nannothemis bella** (Uhler)

MIDDLESEX: near London. BRANT: Glen Morris (NF). HURON: Grand Bend (TNF). PEEL: Snelgrove. MUSKOKA: Go Home Bay. RENFREW: near Stonecliffe.

Floating sphagnum bogs, abundant in some of the bog ponds in the vicinity of Go Home Bay. Carolinian and Alleghanian. The dates range from June 24 (Glen Morris) to Aug. 26 (Go Home Bay). It was common at the bog near Stonecliffe on June 27 and all the individuals were mature, so that emergence must have been over for some time.

116. **Perithemis tenera** (Say)

ESSEX: Pt. Pelee, 29.VI.'29, 1 ♀. KENT: Thames R. near Prairie Siding, 13.VIII.'35, 5 ♂; 8 VII.'36, 1 ♂ seen.

The Point Pelee specimen was taken from the edge of a small shallow lagoon in a large open marsh near the lake shore; the others from a long narrow pond, originally part of the Thames River, from which it is separated by a narrow strip of grassy land, a few yards wide. It is not stagnant, being narrowly connected with the river at one end. This species is strictly Carolinian and, in Canada, is apparently confined to the extreme southwestern part of southern Ontario, where it is evidently very local.

117. **Celithemis elisa** (Hagen)

ESSEX: Pt. Pelee. KENT: Rondeau Park. LAMBTON: Sarnia; Point Edward. NORFOLK: Turkey Pt. (SLT). WELLAND: near Niagara Glen. YORK: Don Valley, Toronto. BRUCE: Southampton; Chesley (GSW). MUSKOKA: Go Home Bay; Dwight, L. of Bays. PARRY SOUND: Simm's L. NIPISSING: near head-waters of French R.

Marshy or boggy lakes and lagoons, fairly common in the Carolinian zone and locally so in the Alleghanian. The earliest date is June 19 (Niagara Glen). At Go Home Bay it was found from June 22 to Aug. 20 and the single specimen from Dwight was taken on Aug. 23.

118. **Celithemis monomelaena** Wmsn.

YORK: Toronto (Hagen, '90c, as *C. fasciata* Kby.; this record repeated by Williamson ('10) under the above name.

It is improbable that this species now occurs in the vicinity of Toronto and the single specimen recorded by Hagen may have been a stray from the south.

119. **Celithemis eponina** (Drury)

ESSEX: Pt. Pelee. KENT: Prairie Siding. LAMBTON: Sarnia. NORFOLK: Turkey Pt. (SLT). YORK: Toronto, Grenadier Pond. LEEDS: near Brockville.

Open marshes and lagoons, abundant in the extreme south; Carolinian. The dates range from June 15 to Aug. 16.

120. **Libellula semifasciata** Burm.

ESSEX: Pt. Pelee. KENT: Rondeau Park; Mitchell's Bay, L. St. Clair (SL & WL). YORK: Toronto; Scarborough. SIMCOE: DeGrassi Pt., Cook Bay, L. Simcoe.

Small, forest streams and marshy bays; Carolinian, abundant at Point Pelee and Rondeau Park. It is an early species, the dates ranging from May 25 (DeGrassi Pt.) to July 15 (Pt. Pelee).

The discovery of this species at DeGrassi Point in 1936 for the first time in over thirty years collecting was surprising. They flew in an open wood in company with large numbers of *L. quadrimaculata* from which they were difficult to distinguish at a short distance. Only 2♂ and 1♀ were taken. This is well out of the normal range of this species.

121. **Libellula quadrimaculata** L.

ESSEX: Pt. Pelee. KENT: Rondeau Park; Big Point, L. St. Clair (WL). NORFOLK: Long Pt.; Turkey Pt. (TNF). HALDIMAND: Oneida Twp. WENTWORTH: Hamilton. BRANT: Glen Morris. PEEL: Snelgrove; Erindale; Gibson L. YORK: Toronto; Woodbridge; Kelly L.; Kleinburg; Schomberg. ONTARIO: Glen Major. DURHAM: Newcastle. PRINCE EDWARD: East Lake. SIMCOE: Cook Bay, L. Simcoe. VICTORIA: Fenelon Falls (WER). HASTINGS: Belleville; Shannonville. FRONTENAC: Silver L. LEEDS: Gananoque R. near Gananoque; St. Lawrence R. near Gananoque; Brockville. LANARK: Innisville; Perth. PRESCOTT: L'Orignal. CARLETON: Bell's Corners; Ottawa; Carp (RHO); Cyrville; Carlsbad Springs; Mer Bleue; Mississippi R. near Galetta. MUSKOKA: Go Home Bay; L. of Bays (JHM); bog ponds between Baysville and Bracebridge; Port Sydney (NKB). PARRY SOUND: Frank's Bay, L. Nipissing. RENFREW: Snake R.; Port Alexander; floating bog near Stonecliffe. NIPISSING: near headwaters of French R.; Cache L. (JHM) and Joe L., Algonquin Park; L. Timagami. ALGOMA: Stony L. (EBW); Little Carp R.; Spanish R. (DSR). SUDBURY: Sudbury (JDE). THUNDER BAY: Orient Bay, L. Nipigon; Gull R. (CSH); Silver I., L. Superior. COCHRANE: Lowbush, Bartlett Pt. and Ghost R., L. Abitibi; Smoky Falls (RVW); Moosonee (MDK). KENORA, Patricia section: Favourable L. region; Attawapiskat R.

Quiet marshy or boggy waters, especially small ponds; generally distributed and abundant everywhere. The season of flight is long, the dates ranging from May 8 (Toronto) to Aug. 19 (Go Home Bay). In the southern counties, however, it is chiefly a spring and early summer form. In the north it is the dominant large libellulid.

122. **Libellula julia** Uhler

ESSEX: Pt. Pelee. KENT: Rondeau Park. MIDDLESEX: London. NORFOLK: Long Pt. WATERLOO: Dumfries N. twp. HURON: Grand Bend. PEEL: Snelgrove; Gibson L. YORK: Toronto; Kelly L. PRINCE EDWARD: East L. BRUCE: Johnson's Harbour (WL); Stokes Bay and Red Bay (NF). SIMCOE: Cook Bay, L. Simcoe. VICTORIA: Fenelon Falls (WER); Bobcaygeon (JHM). HASTINGS: Belleville; Bancroft (JDE). FRONTENAC: Silver L. LEEDS: Brockville. LANARK: Silver L.; Fall R.; Perth; Innisville. CARLETON: MacKay L., Ottawa (AG, AWR); Mer Bleue; Mississippi R. near Galetta. MUSKOKA: Go Home Bay; Port Sydney (RY); bog ponds between Baysville and Bracebridge; Black L., L. of Bays (JHM). PARRY SOUND: Frank's Bay, L. Nipissing. RENFREW: White L.; Port Alexander; near Stonecliffe; Barbut Crk.; Petawawa Forest Res. (VEH). NIPISSING: near headwaters of French R.; Joe and Burnt Island Lakes, Algonquin Park; L. Timagami (AWAB). THUNDER BAY: Orient Bay, L. Nipigon; Bonabec, Gull R. (CSH); Fort William (AGH); Silver I., L. Superior. COCHRANE: Long Pt., L. Abitibi. KENORA: Minaki.

Bog ponds, marshy lakes and bog-margined streams, widely distributed and very abundant, especially in acid waters. A large swarm of this species, together with *Tetragoneuria spinigera* and *T. canis*, was observed at White L., Renfrew Co., on June 26, 1936. The earliest and latest recorded dates are May 24 (Kelly Lake) and Aug. 20 (Go Home Bay). At DeGrassi Pt. it is most abundant in June and its season is usually over by the end of July.

123. **Libellula luctuosa** Burm.

ESSEX: Pelee I. (FMR, NF); Pt. Pelee; Belle R.; Puce. KENT: Mitchell's Bay and Big Pt., L. St. Clair (SL & WL); near Paincourt and Prairie Siding; Dover Centre. LAMBTON: Walpole Id.; Courtright; Point Edward. NORFOLK: Norfolk; Long Pt.; Turkey Pt.; Simcoe. OXFORD: Thamesford. HALDIMAND: Caledonia. WELLAND: Niagara Glen. WENTWORTH: Hamilton. WATERLOO: Dumfries N. twp. HURON: Grand Bend (TNF); Aux Sables R.; Auburn. YORK: Toronto; Maskinonge R. NORTHUMBERLAND: Trenton (JDE). PRINCE EDWARD: East L. SIMCOE: Cook Bay, L. Simcoe. HASTINGS: Belleville. LEEDS: Lyn (GSW). CARLETON: Ottawa; Long I., Rideau R. (FPI); Carp (col.?); Mississippi R. near Galetta.

Marshy bays, lagoons and slow streams, common in the Carolinian zone, local in the Transition. After many years of absence at DeGrassi Point, this species appeared in numbers in 1939 and 1940. Newly emerged specimens were observed in Prince Edward Co. on June 19

and at Belleville and Point Pelee on June 20. At Point Pelee, however, emergence begins earlier than this, as some of the individuals observed on this date were beyond the teneral stage. They were emerging on the Mississippi River on June 26, 1936. The latest date we have recorded is Aug. 31 (Toronto).

124. **Libellula incesta** Hagen

ESSEX: Pt. Pelee. NORFOLK: Turkey Pt. (SLT). SIMCOE: Seabright (CHC). LEEDS: near Brockville. CARLETON?: Ottawa district. MUSKOKA: Kahshe L.; Go Home Bay; Black L., L. of Bays (JHM); near Baysville.

Marshy lakes and lagoons, common at Point Pelee, local northward, mainly Carolinian. The dates range from June 21 (Brockville, 1 juv. ♀) and June 25 to Aug. 11 (Pt. Pelee). It doubtless emerges earlier at Point Pelee.

125. **Libellula pulchella** Drury

ESSEX: Pelee I. (FMR); Pt. Pelee; Puce. KENT: Big Pt. and Mitchell's Bay, L. St. Clair (SL & WL); Prairie Siding; Dover Centre; Chatham; Thames R., Orford twp.; Rondeau Park; Morpeth. LAMBTON: St. Anne I. and Walpole I.; St. Clair R. near Courtright; Point Edward. ELGIN: Port Stanley; Port Burwell; St. Thomas; Springer Crk. MIDDLESEX: London; Arva. NORFOLK: Simcoe (TNF); St. Williams; Long Pt.; Turkey Pt. (TNF). OXFORD: Tillsonburg; Thamesford. BRANT: Dumfries S. twp. HALDIMAND: Port Maitland (NF); Jarvis; Caledonia. WELLAND: Crystal Beach; Welland R. near Hewitt; Gasline; Fort Erie; Chippawa; Niagara Falls; Niagara Glen. WENTWORTH: Hamilton. WATERLOO: Dumfries N. twp.; Kitchener (WJF). HURON: Aux Sables R., Grand Bend; Goderich; Auburn. HALTON: 12-mile Crk., near Palermo; Georgetown. PEEL: Snelgrove; Credit Forks; Erindale. YORK: Toronto; Scarborough; Summerville; Woodbridge; Kleinburg; Thornhill; Maskinonge R.; Highland Crk. PRINCE EDWARD: Bloomfield; Sand Bay; West L.; East L. BRUCE: Southampton; Stokes Bay (NF). SIMCOE: Nottawasaga R., Essa twp.; Cook Bay, L. Simcoe; Wasaga Beach; Singhampton (WER). HASTINGS: Belleville. LEEDS: Gananoque R. near Gananoque; near Brockville. PRESCOTT: L'Orignal; Plantagenet. CARLETON: Ottawa; Rockcliffe (GHF); Long I., Rideau R. (FPI); Carlsbad Springs; Cyrville; Shirley's Bay (CBH); Carp (AWR); Mississippi R. near Galetta and near Pakenham. MUSKOKA: Go Home Bay. PARRY SOUND: Frank's Bay, L. Nipissing. RENFREW: Snake R. NIPISSING: near headwaters of French R. ALGOMA: Thessalon. THUNDER BAY: Fort William. KENORA: Minaki.

Ponds, marshy lakes and slow streams, abundant in the agricultural districts of the south, much less common in the Pre-Cambrian regions, very local in the Canadian zone, only the southern fringe of which it appears to inhabit. It is by far the commonest Libellula in "extreme southern Ontario", being replaced northward by *L. quadrimaculata*. The dates range from June 2 to Sept. 28 (both in the Toronto region). Newly emerged individuals have been found as late as Sept. 28, although

June is the usual month for their appearance. These late individuals come from the shady upper parts of streams at the upper limit of their ecological distribution. The season of flight is practically over by the end of August, September individuals being unusual.

126. **Libellula lydia** Drury

ESSEX: Pt. Pelee (FMR, NKB); Leamington; Puce. KENT: Rondeau Park; Chatham; Orford twp.; Morpeth; Prairie Siding. ELGIN: Port Stanley. MIDDLESEX: Wardsville; London. NORFOLK: Norfolk (TNF); Simcoe (TNF); Long Pt. OXFORD: Thamesford. BRANT: Princeton; Dumfries S. twp. HALDIMAND: Oneida twp. WATERLOO: Dumfries N. twp. HURON: Grand Bend. WELLAND: Forks Crk.; Welland R. near Hewitt; Crystal Beach; Gasline; Fort Erie; Chippawa; Niagara Glen. HALTON: Milton; Palermo. PEEL: Erindale; Gibson L. YORK: Toronto; Kleinburg; Woodbridge; Thornhill. ONTARIO: Glen Major (WER); PRINCE EDWARD: Bloomfield; East L. SIMCOE: Nottawasaga R., near Alliston; Cook Bay, L. Simcoe. HASTINGS: Belleville. LEEDS: near Brockville. LANARK: Perth. PRESCOTT: L'Orignal; Plantagenet. CARLETON: Ottawa; Carp (CHY); Cyrville; Carlsbad Springs; Mer Bleue; Mississippi R. near Galetta and near Pakenham. MUSKOKA: Bracebridge. PARRY SOUND: Sand Crk., Frank's Bay, L. Nipissing. RENFREW: Snake R.; bog pond near Stonecliffe. NIPISSING: Sandy I., L. Nipissing.

Muddy ponds, puddles and quiet pools in small streams in deep soils, abundant in agricultural districts, rare in the Canadian zone, which it penetrates apparently but a short distance. The season of flight is long, the dates ranging from May 31 (York Co.) to Aug. 25 (Tioga). It is most abundant in June.

127. **Tarnetrum corruptum** (Hagen)

ESSEX: Pt. Pelee (FMR, WER, GSW). KENT: drainage canal between Paincourt and Prairie Siding; Rondeau Park. HALDIMAND: Port Maitland (NF). YORK: Toronto. DURHAM: Newcastle (WER). GREY: Camperdown (NF). SIMCOE: Gilford, Cook Bay, L. Simcoe. MUSKOKA: Giant's Tomb I., Georgian Bay. THUNDER BAY: Silver I. KENORA: Minaki (seen).

Shallow beach lagoons and marshy bays, not infrequent in extreme southern and probably also western Ontario, local and of irregular occurrence elsewhere. It appeared on the Gilford stream in some numbers in 1924 but has not been seen there since. The season is long, the dates ranging from June 27 (Newcastle) to Oct. 1 (Toronto). Specimens taken in September at Camperdown, Point Pelee and Toronto were fresh and pale in coloration, while those taken in July at Gilford and Go Home Bay were all fully mature. There thus appear to be two periods or peaks of emergence in Ontario as in Manitoba.

128. **Sympetrum rubicundulum** (Say)

ESSEX: Pt. Pelee and Pelee I. (FMR). KENT: Big Pt., L. St. Clair (SL & WL); drainage canal between Paincourt and Prairie Siding; Dover Centre. LAMBTON: Walpole I.; St. Anne I., St. Clair R. BRANT: Glen Morris (NF). HALDIMAND: Dunnville (WER). WELLAND: Hewitt. HURON: Grand Bend (TNF). PEEL: Erindale. YORK: Toronto; Downsview; Maskinonge R. SIMCOE: Nottawasaga R. near Alliston; Cook Bay, L. Simcoe.

Still marshy waters; abundant in the extreme southwestern part of the Province and doubtless in all the counties bordering Lake Erie; scarcer at Toronto and usually rare at Lake Simcoe; mainly a Carolinian species. Our earliest recorded date is June 21 (Hewitt), the latest Sept. 24 (Dunnville). Specimens taken at Lake St. Clair on June 23 and 24 were all teneral and many have the amber-coloured wings common in tenerals of this species.

129. **Sympetrum decisum** (Hagen)

BRANT: Dumfries S. twp. WATERLOO: Dumfries N. twp. HALTON: Georgetown. PEEL: Snelgrove; Bolton; Erindale; Credit Forks; Gibson L. YORK: Summerville; Toronto; Woodbridge; Kelly L.; Thornhill. ONTARIO: near Balsam; BRUCE: Southampton (TNF); Sauble Beach (NF); Johnson's Harbour (WL). GREY: Camperdown and Meaford (NF). SIMCOE: Bradford; Nottawasaga R. near Alliston; Cook Bay, L. Simcoe; Singhampton (WER). HASTINGS: Belleville. LEEDS: St. Lawrence R. near Gananoque; Brockville. CARLETON: Ottawa; near Cyrville; Mississippi R. near Galetta. MUSKOKA: Port Sydney (NKB); L. of Bays (JHM). RENFREW: Snake R. MANITOULIN: Killarney (NF). NIPISSING: Goose Is., L. Nipissing, and headwaters of French R.; Twin Lakes, North Bay (WER); Algonquin Park (Walker, '06a, as *S. rubicundulum*); Twin Pine Camp, Ottawa R. THUNDER BAY: Silver I., L. Superior; north end of L. Nipigon. COCHRANE: Smoky Falls, Mattagami R. (RVW, GSW); Moosonee (MDK); Nettitichi Pt., James Bay (ESP). KENORA: Minaki; Patricia portion: Favourable Lake region; Attawapiskat L.

Temporary ponds and sloughs, or sometimes quiet pools in small streams; abundant and widely distributed; Transition and Canadian zones.

The season of adult life is long, the dates ranging from June 15 (Snelgrove) to Sept. 5 (Twin Lakes). Adults continue to emerge over a considerable period, tenerals having been taken as late as July 17 (French R.) and July 20 (Brockville). Newly emerged specimens were taken at Moosonee on July 21, but the season is doubtless late at this far northern locality. Specimens taken after about the middle of August are usually worn.

130. **Sympetrum obtrusum** (Hagen)

ESSEX: Pelee I. (NF); Pt. Pelee (GSW, WER). KENT: Big Pt., L. St. Clair (SL & WL); Walpole I.; Rondeau Park. MIDDLESEX: London. BRANT: Glen Morris (NF). LINCOLN: Jordan Harbour (WER). PEEL: Erindale; Snelgrove;

Credit Forks (WER); Bolton; Gibson L. YORK: Summerville; Toronto; Scarborough (AGH); Highland Crk.; Kelly L.; Pottageville; Thornhill; Maskinonge R. ONTARIO: Glen Major (WER). NORTHUMBERLAND: Cobourg (DS). BRUCE: Southampton; Johnson's Harbour (WL); Stokes Bay and Sauble Beach (NF). GREY: Meaford and Camperdown (NF); Thornbury. DUFFERIN: Horning's Mills (WER). SIMCOE: Nottawasaga R. in Essa twp.; Alliston; Cook Bay, L. Simcoe; Washago; Orillia (CHC); 8 miles n.e. of Port Severn (OAP). PETERBOROUGH: Lovesick L. HASTINGS: Belleville. LEEDS: Brockville. CARLETON: Ottawa (AG, JHM). MUSKOKA: Go Home Bay; Kahshe L. and R.; Bala (AGH); Dudley; bog ponds between Bracebridge and Baysville; Lake of Bays (JHM); Huntsville (NF). PARRY SOUND: Nobel; Shawanaga; Point au Baril; French R. (HTW); Frank's Bay, L. Nipissing. RENFREW: Stonecliffe; Heeney Crk. MANITOULIN: Killarney (NF). NIPISSING: Sandy I., L. Nipissing; North Bay (WER); Algonquin Park; Cross and Timagami L. (AWAB); Lowell L.; Tomico R. TIMISKAMING: Latchford. ALGOMA: Sault Ste. Marie, Heyden and Searchmont (EBW); Blind R. (PH). SUDBURY: Sudbury. THUNDER BAY: Orient Bay, L. Nipigon; Longuelac (JLH); Silver I. COCHRANE: Lowbush, L. Abitibi. KENORA: Minaki; Patricia section: Favourable Lake region.

Marshy and boggy ponds, both permanent and temporary; and slow streams; generally distributed; the most abundant of Anisoptera in Ontario.

Emergence may begin before the end of June but reaches its height in July. Many were coming out of a shallow pond near Belleville on June 20, 1936, and numerous tenerals were seen at DeGrassi Point on June 25, 1939. Usually, however, it does not appear in numbers until well on in July when *S. decisum* is fully mature. At Gilford, e.g., specimens taken on July 26, 1923, and July 27, 1932, were newly emerged and the season reaches its climax in August and, in general, is three weeks or more later than that of *S. decisum*. Our latest date is Oct. 11 (Toronto).

131. **Sympetrum costiferum** (Hagen)

LAMBTON: Point Edward. HURON: Maitland R. at Goderich and Auburn. PEEL: Credit Forks (WER). YORK: Toronto. DUFFERIN: Horning's Mills (WER). BRUCE: Southampton; Little Eagle Harbour. SIMCOE: Cook Bay, L. Simcoe; Wasaga Beach. CARLETON: Ottawa (AWR). MUSKOKA: Go Home Bay; Giant's Tomb I., Geo. Bay; Honey Harbour. PARRY SOUND: Skerryvore; Point au Baril; Frank's Bay, L. Nipissing. MANITOULIN: Fitzwilliam I. NIPISSING: North Bay (WER); Talon L. (FPI); Obabika and Wakimaka Crks., Timagami; L. Timagami (WER). ALGOMA: Thessalon. THUNDER BAY: L. Nipigon, north end.

Shallow lakes and ponds with a firm bottom, beach lagoons and sometimes quiet streams; generally distributed except in the far north and often locally abundant.

The season of adult life is rather late, the dates ranging from July 14 (Giant's Tomb Island and Lake Nipissing) to Sept. 16 (Talon L.). Most of the records are for August.

132. **Sympetrum vicinum** (Hagen)

ESSEX: Pelee I. (FMR, NF); Pt. Pelee (FMR, WER). KENT: Orford twp. LAMBTON: Walpole I. OXFORD: Tillsonburg. HALDIMAND: Jarvis. PEEL: Credit Forks (WER); Snelgrove; Erindale. YORK: Summerville; Toronto; Pottageville; Kelly L. DUFFERIN: Horning's Mills (FPI). ONTARIO: Glen Major. BRUCE: Southampton (GSW). GREY: Thornbury. SIMCOE: Cook Bay, L. Simcoe; Washago; Singhampton. PETERBOROUGH: Lovesick L. CARLETON: Ottawa (AG, JHM, CBH). MUSKOKA: Go Home Bay; Bala; Kahshe L. and R.; Dudley; Mactier; L. of Bays. PARRY SOUND: Shawanaga; Point au Baril; Frank's Bay, L. Nipissing. NIPISSING: Porcupine L. (FPI) and Ragged L., Algonquin Park; North Bay (WER); L. Timagami (AWAB); Lowell L. SUDBURY: Sudbury (JDE).

Marshy borders of permanent ponds, lakes and slow streams; generally distributed and abundant throughout Southern Ontario, into Central Ontario.

This is the latest of our Anisoptera to emerge, except *Anax junius*, and one of the last to disappear. Emergence usually begins at Lake Simcoe about the beginning of August and fully coloured individuals are seldom seen before the middle of the month. Except on Pelee Island, where newly emerged adults have been found on July 18, the earliest date we have recorded is July 21 (Snelgrove). The latest date is Nov. 8, 1938, but the season is usually over before the end of October.

133. **Sympetrum semicinctum** (Say)

MIDDLESEX: Arva. WELLAND: Niagara Falls. PEEL: Credit Forks. YORK: Summerville; Toronto; Highland Crk.; Pottageville (JLB); Maskinonge R. ONTARIO: Glen Major (WER). BRUCE: Chesley (GSW). SIMCOE: Alliston; Cook Bay, L. Simcoe; Washago; Singhampton. LEEDS: Lyn (GSW). CARLETON: Ottawa; Black Rapids, Rideau R. (FPI); Mer Bleue (FPI). MUSKOKA: Go Home Bay; Bracebridge. PARRY SOUND: Nobel. RENFREW: Heeney Creek. NIPISSING: Algonquin Park; Obabika Crk. and Cross L., Timagami; L. Timagami (AWAB).

Boggy places in the course of small streams, and spring runs; somewhat local but not uncommon throughout Southern Ontario.

This species is a rather late one and is most often seen in August. Our dates range from June 19 (Niagara Falls) to Sept. 24 (Toronto), but the former is an unusually early record. It has been recorded from Toronto in October (Walker '06b) but without the exact date.

134. **Sympetrum danae** (Sulzer)

ONTARIO: Glen Major (WER). BRUCE: Southampton; Little Eagle Harbour. SIMCOE: DeGrassi Pt. CARLETON: Ottawa (Nat. Coll.). MUSKOKA: Giant's Tomb I., Georgian Bay. NIPISSING: Island Bay Crk. and Obabika Crk., Timagami (AWAB). TIMASKAMING: Latchford. COCHRANE: Lowbush, L. Abitibi; Smoky Falls, Mattagami R. (RVW). KENORA, Patricia section: Favourable L. region; Attawapiskat L.

Marshy ponds, lagoons and boggy expansions of streams; common in the Canadian zone and rarely found south of it. The single specimen from DeGrassi Point was taken in a tamarack swamp and none have been seen in the vicinity of Lake Simcoe on any other occasion. This is the earliest of our records (July 3). Next to this in early appearance is a single teneral individual from the Giant's Tomb Island, taken on July 14. Both of these localities are south of its general range. Specimens were found in emergence at Lake Nipigon on July 20 and at Minaki on July 21. The latest date is Sept. 11 (Timagami) but it probably flies much later than this.

135. **Leucorrhinia borealis** Hagen

KENORA, Patricia section: Favourable Lake region, 24, 28.VI.1938, 4♂, 1♀.

These specimens are all mature and the period of emergence was apparently over. It is known elsewhere to be a very early species

This is the most easterly known record of this northern species of the Central Plains. Its range of habitat is unknown, but at the Pas, Manitoba, it frequents shallow, mud-bottomed lakes or sloughs with a marginal belt of reeds (*Phragmites*).

136. **Leucorrhinia hudsonica** (Selys)

PEEL: Snelgrove. BRUCE: Red Bay (NF). VICTORIA: Bobcaygeon (JHM). LANARK: Silver L. CARLETON: Mer Bleue. MUSKOKA: Go Home Bay; bog pond between Baysville and Bracebridge. RENFREW: Port Alexander; Stonecliffe, floating bog. NIPISSING: Blueberry I., L. Nipissing; Cache L. (JHM); Catfish, Joe and Burnt Island L., Algonquin Park; L. Timagami (AWAB). SUDBURY: Sudbury (JDE). THUNDER BAY: Nipigon; Orient Bay, L. Nipigon; Gull R. (CSH); Fort William (AGH); Silver I., L. Superior. COCHRANE: Lowbush, Upper L. and Ghost R., L. Abitibi; Smoky Falls, Mattagami R. (RVW, GSW). KENORA: Minaki (JHM); Patricia section: Favourable Lake region; Attawapiskat L.; Fort Severn, Hudson Bay (CEH).

Cold marshy waters and bog ponds; common and generally distributed in the Canadian and Hudsonian zones, very local in the Transition, where it is confined to sphagnum bogs. Only a single nymph was found in a floating bog pond at Snelgrove, which is far south of its general range. The Mer Bleue is another isolated southern station, where it is not rare. At Fort Severn on the coast of Hudson Bay it was the most abundant dragonfly.

The time of emergence seems to be about the same in the far north as in southern Ontario. Tenerals were taken at Favourable Lake on June 2 and at Mer Bleue on June 3. The latest dates are July 20 (Fort Severn) and July 24 (Mer Bleue).

137. **Leucorrhinia patricia** Walker

COCHRANE: Smoky Falls, Mattagami R., 26.VI.'34, 2♂; 1, 3.VII.'34, 5♂, 1♀ (GSW). KENORA, Patricia section: Favourable Lake region, 24.VI.'38, 1♂; Fort Severn, Hudson Bay, 3-6, VII.'40, 1♂, 3♀ (CEH).

The few localities where this recently described species has been taken suggest that it is probably a Hudsonian form.

138. **Leucorrhinia glacialis** Hagen

MIDDLESEX: London (Hagen, '90d). MUSKOKA: Go Home Bay; Lake of Bays (JHM); bog pond between Baysville and Bracebridge. NIPISSING: Crown L. (FPI) and Canoe L., Algonquin Park; L. Timagami (AWAB). ALGOMA: Stony L. (EBW); Root R.; Michipicoten (Hagen, '90d). SUDBURY: Sudbury. THUNDER BAY: Fort William (AGH); Silver I., L. Superior. COCHRANE: Lowbush, L. Abitibi; Smoky Falls, Mattagami R. (GSW). KENORA, Patricia section: Favourable L. region.

Marshy or boggy waters; widely distributed in the Canadian zone and sometimes abundant but usually less so than the next species. At Silver Islet, in 1939, it was the most abundant Leucorrhinia. Its occurrence in Middlesex Co. is improbable at the present time.

Our earliest and latest dates are June 17 (Sudbury) and Aug. 19 (Crown Lake).

139. **Leucorrhinia proxima** Calvert

WELLAND: St. Davids (GSW). WATERLOO: Dumfries N. twp. YORK: Kettleby DUFFERIN: Horning's Mills (FPI). SIMCOE: Cook Bay, L. Simcoe; Orillia (JHM). VICTORIA: Bobcaygeon (JHM). HASTINGS: Belleville. PRESCOTT: L'Orignal. CARLETON: Mer Bleue (FPI). MUSKOKA: Go Home Bay; Lake of Bays (JHM); near Baysville PARRY SOUND: Frank's Bay, L. Nipissing. NIPISSING: near headwaters of French R.; Algonquin Park (JHM); L. Timagami (AWAB); Island Bay Crk., Timagami (WER). SUDBURY: Sudbury; Gogama (JKM). ALGOMA: Heyden and Searchmont (EBW); Stony Crk. (col.?). THUNDER BAY: Nipigon; Orient Bay, L. Nipigon; Fort William; Silver I., L. Superior; Gull R. (CSH). COCHRANE: Lowbush, Long Pt. and Ghost R., L. Abitibi; Smoky Falls, Mattagami R. (RVW). KENORA: Minaki; Patricia section: Favourable Lake region; Attawapiskat L.

Still marshy or bog waters; abundant in the Canadian zone, more local in the Transition, somewhat rare as far south as Lake Simcoe. The dates range from June 10 (L. Nipigon) to Aug. 12 (L. Timagami),

140. **Leucorrhinia frigida** Hagen

WATERLOO: Dumfries N. twp. PEEL: Snelgrove. YORK: Kettleby; Maskinonge R. SIMCOE: Cook Bay, L. Simcoe; Severn (JHM). VICTORIA FALLS: Fenelon Falls (WER). MUSKOKA: Go Home Bay; Lake of Bays (JHM); between Baysville and Bracebridge. PARRY SOUND: Frank's Bay, L. Nipissing. RENFREW: Port Alexander. NIPISSING: near headwaters of French R.; Algonquin Park (JHM).

ALGOMA: Stony L. (EBW). SUDBURY: Sudbury. THUNDER BAY: North end of L. Nipigon; Silver I., L. Superior.

Bog lakes and ponds, especially floating sphagnum ponds, abundant in Muskoka and neighbouring parts of the Pre-Cambrian shield; evidently a glacial relict. It is very rare at Lake Simcoe, where its characteristic type of habitat is lacking.

Newly emerged individuals or tenerals were observed at Snelgrove from May 30 to June 29 and at Go Home Bay from June 1 to 24. The latest date recorded is Aug. 19 (Go Home Bay).

141. **Leucorrhinia intacta** Hagen

ESSEX: Pelee I. (FMR); Pt. Pelee; Belle R.; Puce. KENT: Rondeau Park; drainage ditch between Paincourt and Prairie Siding. ELGIN: Port Stanley. MIDDLESEX: London. NORFOLK: Long Pt.; Delhi (GSW). OXFORD: Thamesford BRANT: Glen Morris (NF); Dumfries S. twp. WELLAND: St. Davids (GSW). WATERLOO: Dumfries N. twp. WENTWORTH: Alberton. HALTON: Georgetown. PEEL: Snelgrove; Erindale; Gibson L. YORK: Toronto; Woodbridge; Kelly L.; Bond L.; Wilcox L.; Schomberg; Maskinonge R. ONTARIO: Glen Major (WER); Port Perry. DURHAM: Newcastle. PRINCE EDWARD: Picton (NF); East L.; West L. SIMCOE: Cook Bay, L. Simcoe. VICTORIA: Fenelon Falls (WER); Bobcaygeon (JHM). PETERBOROUGH: Madoc. HASTINGS: Belleville. FRONTENAC: Silver L. LEEDS: Gananoque R. near Gananoque; Brockville. LANARK: Innisville; Perth. GLENGARRY: Lancaster (NJI). PRESCOTT: L'Orignal; Plantagenet. CARLETON: Ottawa; Mer Bleue; Bell's Corners; Cyrville; Mississippi R. near Galetta and near Pakenham. MUSKOKA: Go Home Bay; L. of Bays (JHM). PARRY SOUND: Sand Crk. and Frank's Bay, L. Nipissing. RENFREW: Snake R. NIPISSING: Goose Is., L. Nipissing, and headwaters of French R.; L. Timagami (WER). ALGOMA: Sault Ste. Marie.

Marshy bays, ponds and slow streams, rarely in sphagnum bog ponds; generally distributed and very abundant in southern Ontario, scarcer northward. The season is long, the records from Lake Simcoe ranging from May 24 to Aug. 26. A teneral female with abnormally dark flavescent wings was taken on Aug. 26, 1907. In Toronto and Newcastle it has been taken as early as May 20 and usually only a few are left by the end of the first week in August.

142. **Pachydiplax longipennis** (Burm.)

ESSEX: Pelee I. (FMR, NF); Pt. Pelee. KENT: Big Pt., L. St. Clair (SL & WL); drainage canal between Paincourt and Prairie Siding; Rondeau Park. ELGIN: Port Stanley. NORFOLK: Long Pt. HALDIMAND: Port Maitland (NF). WELLAND: Niagara Falls. WENTWORTH: Hamilton. YORK: Toronto. SIMCOE: DeGrassi Pt., Cook Bay, L. Simcoe. PRINCE EDWARD: East L.

Marshy ponds or lakes and lagoons; Carolinian. It is fairly common from Toronto southward but had never been taken farther north until 1933, when a single male was captured at the creek near DeGrassi

Point on July 12, and at least one other was seen there on the same day. These are the first observed in this locality in more than thirty years of collecting there and they have not been seen since. The dates range from June 11 to July 26 (August, Walker, '06). Tenerals were observed at East Lake on June 19.

143. **Erythemis simplicicollis** (Say)

ESSEX: Pelee I. (FMR); Pt. Pelee; Puce. KENT: Dover Centre; Rondeau Park. NORFOLK: Turkey Pt. (SLT). OXFORD: Thamesford. WELLAND: Welland R. near Hewitt. WENTWORTH: Hamilton. HURON: Egmondville (JGO); Auburn. YORK: Toronto. PRINCE EDWARD: East L. SIMCOE: DeGrassi Pt., Cook Bay, L. Simcoe. LEEDS: Gananoque R. near Gananoque; Lyn (FPI, GSW, CHC). CARLETON: Ottawa.

Marshy ponds and slow streams, common in the Carolinian zone but very local and usually scarce north of Toronto. The earliest and latest dates are June 19, 20, 21 (East L., Toronto, Gananoque R., Rondeau Park) to Aug. 19 (DeGrassi Pt.). Many specimens seen on a tributary of the Gananoque River on June 21 were all teneral. It appears to be most abundant in July.

144. **Pantala hymenea** (Say)

ESSEX: Pelee I. (FMR); Pt. Pelee, 17-27. VII. '20.

This species was observed at Point Pelee on several occasions by Mr. N. K. Bigelow and the writer. Individuals were flying over the beach but were extremely difficult to capture, only 2♂ and 1♀ having been taken. They were also seen in flight by the writer at Rondeau Park, Kent Co., on June 24 and at Point Pelee on June 25, 1934. There is little doubt that they breed here.

145. **Pantala flavescens** (Fabr.)

LAMBTON: Point Edward, 14 VIII. '35, 1♂.

This was a young individual and was taken from the edge of a shallow lagoon from which it had doubtless emerged within a day or two. The lagoon was in a depression in a sand-dune area near the beach of Lake Huron. It is an almost cosmopolitan species, occurring in North America as far north as the Carolinian zone and sometimes, as a stray, still farther north. Single individuals have been taken in two other Canadian localities, viz., Husavick, Man., and Montreal, Que.

146. **Trapezostigma carolina** (L.) [*Tramea carolina* (L.)]

ESSEX: Pt. Pelee (FMR, GSW, WER). YORK: Toronto.

These localities represent the extreme northern limit of this southern

species. The single specimen from Toronto was taken on May 24; those from Point Pelee on June 16 and in late August (exact date lost).

147. **Trapezostigma lacerata** Hagen

ESSEX: Pelee I. (FMR). Pt. Pelee; St. Joachim; Belle R.; Puce. KENT: Rondeau Park. NORFOLK: Long Pt.; St. William's; Norfolk (TNF). OXFORD: Thamesford. BRANT: Princeton. WELLAND: Welland R. near Hewitt; near Niagara Glen. YORK: Toronto. SIMCOE: Lefroy, Cook Bay, L. Simcoe.

Open marshy lagoons and bays; Carolinian; common in the counties along Lake Erie and formerly at Ashbridge's Bay, Toronto, a wanderer as far north as Lake Simcoe, where a single female was taken on June 3, 1933.

There are two periods of emergence (as in *T. carolina*). The earliest date in our records is May 30 (Rondeau Park) and those taken at this locality on our arrival on June 20, 1922, were fully mature, while tenerals appeared at Point Pelee on Aug. 21 and 22. Fresh specimens were flying at Ashbridge's marsh on Sept. 12 and 14, 1933. The latest date we have recorded is Oct. 11, 1934 (Ashbridge's marsh) when several individuals were seen in flight, one captured being still quite fresh.

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of the

Royal Canadian Institute

VOLUME XXIII

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